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ULTRA-VIOLET RADIATION AND ACTINOTHERAPY

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WITH FOREWORDS BY

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SECOND EDITION

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NEW YORK
WILLIAM WOOD & COMPANY
MCMXXVII

EDINBURGH
E. & S. LIVINGSTONE
16 & 17 TEVIOT PLACE

Printed in Great Britain
by The Riverside Press Limited
Edinburgh

WB
480
R962u
1927

FOREWORD

By Sir Oliver Lodge, F.R.S., D.Sc., LL.D.

The interaction of ether and matter is attracting more attention to-day than ever before. The quiver of the ether that we call radiation has the remarkable property of ejecting electrons from atoms, and thereby of exciting not only vision and photographic action, but of effecting a variety of other chemical changes. It is by this means that plants absorb radiant energy and grow; it is thus that trees are enabled to form their woody fibre from constituents of the air and moisture. Solar energy, received through the ether and transmuted on arrival into various forms, is responsible for all our activities. What the effect of radiation on human bodies may be, we are only beginning to find out. Pigmentation produced in the skin shows that the effect is by no means negligible; and now clinical work on the effect of radiation, both natural and artificial—especially radiation of frequency too high to affect, except prejudicially, the retina of the eye—is leading to results of obviously great interest even to a layman. Such rays are found to be conducive to health: the deprivation of such rays, by the unthinking pollution of town atmosphere, must have seriously impaired the health and well-being of the urban community. We are waking up to large possibilities of improvement in these directions.

Naturally, I express no opinion on purely medical matters; but a book dealing with this comparatively new and highly promising subject, by people with medical training, physical knowledge, and extensive and rapidly growing experience, should be welcome. I judge that this is such a book, and commend it accordingly.

Oliver Lodge

FOREWORD

By Sydney Walton, C.B.E., M.A., B.Litt.

I am the merest layman and very shyly take my stand at the threshold of this book which tells of learning linked to life. But, on second and braver thoughts, why should a layman be hushed and dumb? It is his duty to rejoice when the light of healing comes. He gives thanks to see the shadows of disease grow less and praises all who sincerely seek to do battle with the mysteries of suffering.

Perhaps the authors of this volume, their diary, so to speak, of experiment and research, asked me to write a Foreword because they honour me with their friendship and all true friendship is as sunshine to the soul. I have known Dr William Russell for many years, but it is of his father I would relate a memory or two—his father, to whom this book must be a joy in his eventide.

Dr Russell's father became an intimate friend of mine, and at his hospitable fireside I have many times listened to him on subjects touching the health of the people. He spoke with the eloquence which comes from compassionate contact with life. He turned my thoughts in the direction of preventive medicine which, in my layman's way, I translated: "The doctor as lighthouse rather than lifeboat."

It was he who introduced me to the late Sir Napier Burnett, who was then in Newcastle-on-Tyne, and I

was able at a later stage, through the noble generosity of Mr L. G. Sloan and Sir Harold Bowden, Bart., to assist in making it possible for Sir Napier to come to London and devote himself to his heart's desire, which was the evangel of health. Great and splendid work he did until he was stricken untimely down.

The meaning of this most personal Foreword is that Dr Russell's father sent out his inspirations far and wide, and as the nation was debtor to Sir Napier Burnett, so it was to him, in that he was the cause of the other's apostleship. And now the son and his accomplished wife continue the discipleship which the father adorned. Most sincerely do I give welcome to this book. May it be, as it intends, a lamp of knowledge to shine among the shadows!

The authors wish to express their thanks to Dr A. Reyn, Dr Rollier and Sir Henry Gauvain, for the kindness shown to them when visiting the Finsen Institute, Copenhagen, Leysin and Alton, and for the help so readily given.

They would also like to acknowledge the courtesy shown by Professor Leopold Freund, Professor Volk, Dr Cemach and Dr Ostermann during a recent visit to Vienna, and also Dr Saidman's kindness in Paris.

Their thanks are also due to Dr Rosselet, Professor Todd, Professor Firth, Professor Hutchens, Dr Birkett Wylam, Mr John Secker, M.Sc., and Mr T. Bambridge; also to Dr R. L. Bell for help in reading the proofs.

It is also desired to acknowledge the kindness of the various firms who have so willingly lent blocks for illustrations; and also the unfailing courtesy and help of the publishers, Messrs E. & S. Livingstone.

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INTRODUCTION

THIS treatise is submitted with the modesty which best becomes those who realize that we probably stand at the dawn of a new era in medical practice. There is no doubt that a great change is taking place. Preventive treatment is, at last, beginning to take its rightful place in medicine.

Great interest is being displayed by the public in new healing agencies, and there is a definite tendency on its part to desire the substitution of physical methods of cure for medicinal in an increasing number of diseases.

H.R.H. the Prince of Wales in his Presidential Address at the 1926 meeting of the British Association, Oxford, cleverly epitomizes the value of ultra-violet radiation. "Closely linked," he says, "with the discovery of vitamins has been the more recent development of knowledge concerning the need of sunlight for health, in man and his fellow-animals as in plants. We know now that crippling deformity appears in the growing child unless he receives his proper share of the vitalizing rays of the sun, either directly or through the presence in natural foods of vitamins which these rays have produced. Sunlight, or its artificial equivalents, has some importance already in the treatment of disease; but a realization of its significance for health has a much greater importance in preventive hygiene.

There can surely be no plainer duty for a State charged with the health of an industrial civilization than to promote with all its resources the search for such knowledge as this, as well as to provide for its application when obtained."

Major-General Seely, speaking at a recent hospital meeting in London, said: "Nearly every disease can be cured by fresh air and sunshine. A distinguished scientific friend of mine said to me recently: 'In twenty years' time there will be only three means of treating the human body—surgery, bacteriology and heliotherapy. The third of these three will be the most important, and all kinds of treatment now regarded as essential will disappear.'"

This may prove to be an exaggeration, but it, at least, shows the trend of contemporary scientific thought.

This book has been written by two medical practitioners, one of whom served as an orthopædic surgeon on the staff of a large War Pensions Hospital, and while there had many opportunities of observing the beneficial effects which followed upon the treatment of patients exposed to sunlight in the open air.

The authors will be well content if they have been able to make a few suggestive hints, and they can at least claim that their study of this subject has been that of enthusiasm tempered only by the obligation of painstaking.

The authors have had personal experience with a large number of different models of ultra-violet lamps, and they have therefore described every well-known type of carbon arc and quartz mercury vapour lamp,

as they feel that it is unwise to limit one's interest to one type of lamp, just as it would be equally illogical, for instance, to always prescribe laudanum every time one wished to administer a sedative.

The authors have generally found the various different types of lamp satisfactory, particularly the air-cooled mercury vapour lamp; the difficulty being, not an inability to get sufficient ultra-violet radiation, but trouble in gauging the correct amount required by the patient.

Probably the tungsten arc lamp gives off more ultra-violet radiation than the quartz mercury vapour lamp, but it has some disadvantages.

The initial cost, it is true, is less, but the upkeep, owing to the high price of the tungsten electrodes, is greater. Moreover, it produces unpleasant fumes, and, as it is hand-regulated, it needs constant attention. The carbon arc lamp is mostly used in hospitals where several patients are being treated at the same time. All these different types of lamp produce ultra-violet rays satisfactorily, both in regard to quantity and quality. They all have their little advantages and disadvantages.

The mercury vapour lamp's chief defect is its fragility and comparatively short life; the tungsten arc's, the fumes it produces and the cost of running it; the carbon arc's, the great cost of the current and the carbons used.

But as a means of producing ultra-violet rays any one of these types can be recommended.

Improvements in the design of apparatus are taking place every day, and yet the whole subject is still in

its infancy. Selective filters will probably be more frequently used than at present.

This book describes principally the use of ultra-violet radiation in the authors' own practice, and they trust that their experience may be helpful to other practitioners who are contemplating the use of this form of treatment.

Over a year ago the authors endeavoured to encourage the more general use of ultra-violet radiation by doctors in general practice. They did this because they realized what a severe set-back actinotherapy would suffer if it were indiscriminately exploited by the unqualified, and that the greatest opportunity of real progress lay in its adoption by the general practitioner, who, after all, sees the beginnings of disease and conditions when they are most amenable to treatment.

But, alas, the year 1926 has seen many lay attempts to commercialize actinotherapy, oblivious of the fact that its uncritical employment is both dangerous and futile and that correct diagnosis is imperative.

It is of supreme importance that this valuable remedial agent is not carelessly allowed to pass into unqualified hands, otherwise doctors will be deprived of a wonderful opportunity of securing additional scientific knowledge of one of the most potent instruments of healing.

Luckily the remedy, which rests almost entirely with the medical profession itself, is simple.

When medicinal treatment alone has been disappointing in such conditions as lupus, *Alopecia areata*, hay fever, rickets, spasmophilia, tetany, Parkinsonism following *Encephalitis lethargica* (to mention only

a few conditions at random), it is surely unwise for the sufferer to be told that nothing more can be done; this advice generally results in the patient rushing to the nearest unqualified practitioner.

In suitable cases it is certainly the duty of medical men to advise their patients to have appropriate physical treatment. It is also very unwise for doctors to send their patients to the unqualified when they desire them to undergo a course of ultra-violet radiotherapy, because, through lack of competent knowledge, the results naturally are often mediocre, and, moreover, disaster sometimes occurs. Some medical men imply that the good results which follow actinotherapy are entirely due to suggestion. Even if they were (which they are certainly not), does not the patient most of all desire the cure of the condition?

Has a bottle of medicine no psychical effect? Many may remember a recently deceased patent medicine with an intriguing smell which did not seem to be entirely lacking in this respect.

Is not the wholesome mental stimulation of ultra-violet radiation superior to the unpalatable Freudian theories?

Nagelschmidt—determined to meet this rather unfair criticism—specially treated two hundred cases of alopecia, with success, because he said that the suggestion of psychical effect could hardly be advanced in this disease, which is so resistant to medicinal treatment.

Many criticize the large number of diseases which workers claim they have cured or benefited by ultra-

violet radiation; but are not most diseases benefited by the raising of the natural resistance of the body?

Solar radiation is essential to all forms of life. Is it, therefore, unreasonable to make use of the different rays in disease?

The authors are still convinced that there is a vast and beneficent field for a substantial part of this work in the hands of the general practitioner, and that the necessity by no means exists for all the curative work of this nature to be relegated to the specialist, though there are certain forms of this treatment which must be handed over to the actinotherapist.

To-day we have an almost complete realization of the fact that, just as the sun gives light, so, too, has sunlight a curative influence upon disease. The trouble is that we do not get enough sunlight. Happily, to-day, we know how to produce it artificially. In our War Pensions Hospital experience it was observed that patients who had languished in the wards responded at once when put outside on the open-air balconies. Foul discharging wounds which had persistently resisted treatment immediately began to improve; the men's pale cheeks began to colour; their appetites returned, and generally their condition improved. We never met a patient who, having once been put outside, wanted to come in again. Later, in general practice, we have seen the same wonderful change.

One case comes particularly to mind—that of a man suffering from pernicious anæmia. We persuaded him to stay out-of-doors in the sun for gradually lengthening periods. He had a revolving hut placed

in his allotment, and here he was able to undress, to don a small bathing suit, and to have his graduated sun bath. He improved wonderfully; but bad weather came, his treatment became very spasmodic, and he seemed to slip back a little each time that he was unable to get outside. So we resorted to artificial sunlight on sunless days. We obtained a quartz mercury vapour lamp and began systematic treatment with graduated exposures, until finally the patient was having a total daily treatment of forty minutes' duration.

The effect was most inspiring. The periods of relapse, so characteristic of pernicious anæmia, ceased; he was able to attend his work for several hours daily; the number of his red corpuscles increased, and the improvement continued for several months. Unfortunately a sudden attack of influenza took him away after only one day's illness. He lived for five and a half years from the time the disease was definitely diagnosed from the blood examination.

Having the lamp, we began using it for the treatment of other conditions in which we thought improvement could be expected—especially those cases in which open-air treatment had been of help, and also in certain skin conditions. Patients convalescing after acute illnesses did particularly well, and equal success was observed in cases of rickets which had not responded satisfactorily to cod-liver oil treatment. Cases of hyperpiesis which had remained stationary with medicinal treatment improved greatly with ultra-violet radiation. Very soon the lamp became almost indispensable.

No single therapeutic agent can be a "cure-all." Each has its place in medicine, and a new method of treatment is brought into disrepute only when extravagant and unsubstantiated claims are made for it. Medicinal treatment, physiotherapy, dietetics, climatology—all have their appropriate uses. We realize only too well that treatment with natural sunlight is the ideal method in many different forms of disease. But in spite of Willett's wonderful daylight-saving measure it is an ideal which is often difficult to attain, particularly among the urban working-class population. In industrial towns suitable open spaces are often entirely absent, or difficult of access, and a working-class mother, especially if there be several small children, finds difficulty in taking these children out-of-doors for a sufficient length of time. Slums and smoke pollution aggravate the problem. Too long has the present state of affairs been tolerated. Enlightened town-planning will avoid these grave defects in the future, and no longer will the promiscuous creation of slums be allowed.

Even now it is insufficiently realized how deleterious are the effects of smoke; how it shuts off the beneficial rays in sunlight, and what a tremendous amount of extra work it causes in the home, especially in regard to cleaning and washing. Household hangings which remain clean in the country for a year have to be washed every two or three weeks in an industrial town.

Food must not be adulterated, water must not be contaminated, yet anyone can pollute the air we breathe practically without hindrance.

The actual weight of air we inhale in twenty-four hours is six times heavier than the food we eat in the same period. If unpalatable food has been taken we can rid the system of it, but this is not possible in regard to the air we breathe.

During recent coal strikes, with the accompanying closing-down of factories, the increase in visibility was most noticeable, and one then realized how great is the atmospheric pollution by smoke.

Hundreds of thousands of pounds sterling are being spent annually in this country in replacing stone work which has been destroyed by the sulphuric acid formed from smoke.

The erection of factories on the leeward side of towns is helpful in new town-planning proposals. But really of much more importance is the total abolition of smoke, and one way in which this could be achieved is by lowering the cost of the electrical unit. It is its dearness which at present hinders its more universal adaption. Of course the use of coke, coalite and other smokeless fuels aids smoke abolition, but the cheapening of the cost of the electrical unit is the crux of the matter. The more general electrification of railways and factories would play its part too.

Our hospitals for in-patients should, if possible, be in the country, away from the smoke of towns, and the facilities for putting patients outside on verandas or balconies greatly increased. Again, indirectly, the health of the community suffers by the consumption of milk from cows grazing in fields adjacent to towns, and market produce grown under similar conditions.

We would urge the more general use of natural sunlight in the treatment of disease, or, failing that, of artificial sunlight. We think general practitioners, after suitable instruction, should, as we have said, use this method of treatment themselves in a great number of cases, so as to make it available for every class of the community. The cost of the administration is not too great to make its universal adaption possible.

Ultra-violet radiation is certain to be employed increasingly in the future. Every hospital will need to install "sun ray" lamps, particularly special hospitals for diseases of the skin, throat, nose and ear, and eye. Ante-natal clinics, tuberculosis clinics and sanatoria, and mental hospitals will also require ultra-violet equipment.

The value of ultra-violet radiation in surgical practice, particularly in the operating theatre, is just beginning to be realized, and the results of the pioneer work at the famous Necker Hospital, Paris, will soon be spread world-wide.

Special ultra-violet clinics will undoubtedly have to be established in the centre of our densely populated urban districts, so as to be able to cope satisfactorily with the need for preventive and curative treatment of this nature.

General hospitals alone will never themselves be able to satisfy the ever-increasing demand for ultra-violet radiation, more especially where (as so often happens) X-ray diagnosis, electrical treatment and ultra-violet radiotherapy are all crowded into one department, and where X-ray diagnosis alone often

makes such exacting claims on the time of the honorary medical officer.

The authors consider that these special ultra-violet clinics are destined to become the most valuable system of all, because by their means a fair chance can at last be given to preventive treatment.

ULTRA-VIOLET RADIATION AND ACTINOTHERAPY

CHAPTER I

HISTORICAL

Sun Worship among Primitive Races, and the Greeks and Romans—The Industrial Revolution—The Discovery of the Spectrum and of Invisible Radiation—Pioneer Discoveries in Light and Electricity—The Pioneers of Actinotherapy—A Short Account of Finsen's Life

In the beginning God said: "Let there be light." The sun was worshipped as the source of both life and light in very early times. Light was recognized as the bringer of health and happiness, as the power which overcomes the dread darkness associated with death and destruction.

The pastoral Aryans worshipped the sun, the great Lord of all, to whom they gave the name Dyaus, from which is derived the Latin *deus* and our own word Deity. The Persians were sun worshippers too, and gave the name Mithra to their god; in Egypt the sun-god was called Ra; in Greece, Helios; and was known by the Romans as Sol. The temple at Heliopolis was a centre for sun worship.

Hippocrates, the father of medicine, who lived on the little Greek island of Cos about 460-370 B.C., practised heliotherapy at the temple named after Æsculapius, the son of Phœbus Apollo; Cornelius

Celsus and Galen, who lived about A.D. 130-200, also used sun treatment. Covering the head and exposing the rest of the body to the sun was a favourite practice among the Greeks and Romans.

Cicero describes the solaria which wealthy Roman citizens often had constructed at their country villas, the solarium generally being a terrace on the flat roof of a house.

In Peru the Incas were looked upon as gods, being considered children of the sun; they treated syphilis by heliotherapy. In our own country the Druids deified the sun, Stonehenge being associated with this worship; and is not our Sabbath still called Sunday? With the advent of Christianity there was a revulsion against all pagan practices and, during the Dark Ages, heliotherapy fell entirely into oblivion, and there was no appreciable revival until the latter end of the eighteenth century.

Even to-day fire worship plays an important part in two great religions—the Parsees worship fire as the visible symbol of Ahura-Mazda, the eternal principle of light, and the Brahmans consider light divine.

In Southern Bolivia the Chiriguanos Indians often pray to the sun, using these words: "Thou art born and disappearest every day, only to revive always young; cause that it may be so with me."

This country has been very apt to overlook the vital importance of sunlight to the human race, especially since the beginning of the industrial revolution, coming as it did with the use of coal for producing power. New towns rapidly sprang up, badly laid out, with no attempt at town-planning. Factories were

also hurriedly built, and were allowed to use coal very wastefully, with the consequent production of large quantities of smoke, which cut off most of the valuable rays of sunlight.

The taxes which had been levied on windows were repealed only in 1851; and even now bricked-up windows can still be seen, showing where an endeavour had been made to lighten the burden of the tax.

Narrow streets were built where the sun could rarely shine.

Sir Oliver Lodge explains the problem simply in the following words:

"When the most efficient parts of sunlight are excluded, the organisms which flourish are of the lowest kind; and the higher organisms are apt to succumb to their ravages when unaided by the beneficial influence of sunlight."

It is too often forgotten that sunlight contains, besides light and heat, other forms of radiant energy very helpful to the most wholesome forms of growth.

The centuries-old saying, "Light is the life of man," is only now beginning to be realized in its whole significance.

Heliotherapy is therefore not a new form of treatment, but a very old practice revived. It teaches only what Hippocrates, Celsus and Galen preached hundreds of years ago.

In 1666 Sir Isaac Newton discovered that sunlight is composed of the different colours—red, orange, yellow, green, blue, indigo and violet—and he opened up the path to the various fields of invisible radiant energy and to the production of artificial therapeutic

rays by his discovery of the spectrum. Even Newton saw only the spectrum of visible light. And he also

FIG. 1.—Oscar Bernhard, M.D., St Moritz.

thought that luminous bodies actually shot out small particles or corpuscles with tremendous velocity, the corpuscles being able to pass only through transparent bodies.

1678. Christian Hugheyns formulated the wave

theory of light, which assumes that there is a universally diffused medium which undergoes some form of regularly repeated physical change.

1733. Dufay discovered that there are two kinds of electricity.

1774. Faure treated ulcers with solar rays and soon after other workers used lenses to focus the rays of the sun on to open wounds.

1777. Scheele described the action of light on certain silver salts.

1779. Ingenhouse showed that it is the light of the sun and not its heat which enables the chlorophyl of the green leaf to dissociate carbon dioxide.

1779. Bertrand published essays on *The Influence of Light on Living Organisms.*

1799. Volta announced the discovery of the voltaic battery.

1800. Sir William Herschel, repeating Newton's experiment, placed a clinical thermometer before each colour of the spectrum, and noticed that when it was placed beyond the limit of the visible red rays it continued to rise, which proved the existence of invisible radiant energy. These rays, owing to their position in the spectrum, were named "infra-red"—or heat—rays.

1801. Ritter, noticing that silver chloride was blackened by invisible rays situated beyond the limit of the visible violet rays, rightly concluded that other radiant energy is present in the ether which is invisible to the eye. These radiations, owing to their position in the spectrum, he termed "ultra-violet" rays, and these are the rays which have been proved

to exert the greatest therapeutic influence in the solar spectrum.

1802. Sir Humphry Davy first produced the electric arc. This epoch-making discovery made artificial phototherapy possible.

1815. Fraunhofer discovered the dark lines in the solar spectrum.

1820. Grotthus formulated the photo-chemical absorption law.

1820. Hans Christian Oersted discovered that a magnetic field is created round a wire connecting the two terminals of a voltaic battery.

1831. Faraday made the fundamental discovery that an electric current is induced when a conductor cuts across lines of magnetic force; this made the construction of the dynamo and other electrical apparatus possible. He found that an electric current is created in a wire loop by simply moving a magnet towards and away from it.

1835. Daguerre took the first photographs.

1845. Bonnet drew attention to the great value of heliotherapy in the treatment of tuberculous osteo-arthritis, advising both local and general treatment.

1854. Bunsen perfected the spectroscope.

1862. J. B. F. Foucault and A. H. L. Fizeau devised an experimental method of determining the velocity of light.

1865. Clerk Maxwell demonstrated that light is due to electro-magnetic vibrations in the ether, and that the vibrations all travel through space at the same speed.

1876. Professor A. H. Rowland discovered that if

an electrified body is moved a magnetic field is created round it.

1877. Downes and Blunt proved the bactericidal properties of light.

1879. Sir William Crookes, while experimenting with a vacuum tube excited by a high-tension source of electricity, discovered cathode rays; later, in 1897, Sir G. G. Thomson showed that these rays consist of particles of negative electricity called electrons.

1885. A. A. Michelson determined the velocity of light to be 186,326 miles per second.

1886. Heinrich Hertz discovered by means of his oscillator that electro-magnetic waves can be produced in the ether which have all the fundamental properties of light waves, but differing from them in wave-length, frequency and penetrating power.

1889. Widmark showed that it was the ultra-violet rays in sunlight which cause erythema and pigmentation.

1893. Finsen published his early experiments on the physiological action of light, and also announced the results of his treatment of tuberculosis of the skin by means of the "Finsen Light."

1895. William Conrad Röntgen discovered X-rays.

1896. Becquerel discovered the radiation given off by uranium.

1897. Sir G. G. Thomson demonstrated the existence of electrons.

1898. The Curies discovered radium and other radio-active substances.

1902. Bernhard of Samaden treated wounds and tuberculous lesions with sunlight.

1903. Dr Rollier opened his first clinic at Leysin, in the Vaudois Alps, where he obtained excellent

Fig. 2.—Augustus Rollier, M.D., Leysin.

results in the treatment of tuberculosis, especially of the surgical type, by insolation in the brilliant Alpine sunshine.

1904. Kromayer designed the quartz mercury vapour lamp.

1913. Reyn commenced general carbon-arc-bath treatment.

FIG. 3.—Axel Reyn, M.D., Medical Superintendent, Finsen Institute, Copenhagen.

1918. Huldschinsky first showed the value of ultra-violet rays in the cure of rickets.

1924. In December 1924 the Sunlight League was formed, with the late Queen Alexandra as its patron. The League has for its objects the abolition of smoke,

dirt and slums; the restoration of the light of the sun to all who live in cities; and the education of the people to the new knowledge of sunlight as a means of health, teaching that it is a stimulant, a tonic, and nature's universal disinfectant.

1926. In March the monthly magazine, *The British Journal of Actinotherapy*, incorporating *Modern Sunlight*, first appeared.

A Short Account of Finsen's Life

Niels Ryberg Finsen, the founder of modern actinotherapy, was born on the 15th of December 1861, at Thorshavn, in the Faroe Islands, where his father was chief magistrate. The Finsens are, however, an old Icelandic family. Finsen's father was married twice, Niels Ryberg Finsen being one of the four children of the first marriage. One of his brothers was Postmaster-General in Copenhagen. As a boy Finsen was very fond of an outdoor life, climbing, fishing and shooting, and he did not relish the restrictions to his personal liberty when he was sent to a boarding school in Denmark. At school he was rather a backward pupil, one of his reports reading: "Niels Finsen is a thoroughly good boy, but his abilities are small, and he is rather lacking in energy."

When Finsen was fifteen years of age his father took him from the Danish boarding school and sent him to Reyjavik, the capital of Iceland, to continue his education, where he remained for six years.

The drawback of this change was that everything

had to be learned in a new language—and by no means an easy one. The severe climate of Iceland, the cold sunless winters, did not help Finsen physically,

FIG. 4.—Professor Niels Ryberg Finsen.
Born, 1861, Faroe Island; Died, 24th September 1904, Copenhagen.

and he soon began to feel that something was amiss. Although he was intensely fond of climbing he found he had to give up this strenuous form of sport, and

content himself with yachting and shooting—he was an excellent shot and won many medals.

In 1882 he became a medical student at Copenhagen, where he boarded with a hundred others at Regensen's. While there he found that he could work better in his chum's room, which was sunny, than in his own more cheerless room; and later, realizing the stimulating effect which sunshine had on him, he spent a part of each day walking up and down the sunny pavement at St Annceplads, where he had come to lodge.

Finsen now began to wonder why sunshine had this wonderful effect on him, but on consulting his copy of Hermann's *Physiology* he was unable to find any reference to light in it except in connexion with sight.

A little incident occurred about this time which greatly interested Finsen. He saw a cat lying contentedly sunning itself on a flat roof just below his window. After a short while the shadow reached it and the cat moved into the sunshine again, which little action was repeated several times, and Finsen realized that by instinct the cat sought the sunshine. This was the genesis in Finsen's mind of the sun or light bath, and later he read about the Greek and Roman solaria.

In 1889 Finsen became engaged to Ingeborg, daughter of Bishop Balslev.

In 1890, when Finsen had finished his medical course, he was appointed demonstrator of anatomy. He had always shone at this subject, as he was particularly clever with his hands. He continued his anatomical work for three years, but suffered from ill-health during the whole of the period.

While on holiday at his father-in-law's house at Ribe, in 1892, Finsen first began experimenting with sunlight. He tried the effect of it on his own skin. First he painted a two-inch strip on his forearm (which was usually covered by his coat-sleeve) with Indian ink, and exposed the arm to strong sunlight for nearly three hours. Some hours later he washed off the ink and found that the skin underneath was quite white, while the surrounding skin was an intense red, there being a very marked contrast between the two. Two days later he noticed that the redness had disappeared but the arm was pigmented—excepting for the white area, which was unchanged. Once more he exposed his arm to the sun, but this time without painting it, and later he found that the white area now turned red, while the surrounding skin was scarcely affected.

This phenomenon answered a riddle about which he had often pondered—why the negro was given the warmest coloured skin, and people living in northern countries the coldest.

Finsen then began to wonder what the effect of sunlight would be on the skin if the resistance of the body were lowered by disease, when the effect was so strongly marked on normal skin, and he later evolved the "Red Room" treatment of smallpox, as he had noticed that in this disease the scars are usually most marked on those parts of the body usually exposed to light.

He made the suggestion that smallpox patients should be treated in rooms with red windows similar to those used in the photographic dark-room. There

was no smallpox in Copenhagen at the time, but in the summer of 1893 an epidemic broke out in Bergen, when Finsen's suggestions were followed out, with great success.

In November 1893 Finsen wrote an article on "The Harmful Influence of Chemical Rays on the Animal Organism," and in this he showed that bacteria thrive best in darkness and can be killed by exposure to light.

Finsen's first work aimed at the exclusion of the blue-violet rays of light; now he began to study their effect on organisms. He differentiated certain animals into those which seek the light and those which prefer darkness.

First he made a box, the lid of which was made of strips of different coloured glass—red, yellow, green and blue. He put some earthworms into the box and found that in a very short time they were all lying under the red strip of glass.

Butterflies were next tried, and after a short while most of them were moving about under the blue glass, while a few settled under the red glass, but these were all in a resting condition with folded wings.

Ripe salamander eggs, with the embryos plainly visible in the shells, were also placed under these same coloured glasses, and the number of movements counted. Forty-six movements were noticed under blue light, eight under green, none at all under yellow, and six under red.

Finsen came to the conclusion that light, besides having illuminating and heat-producing properties, has also a "chemical effect," which can be destructive

to life (as is seen in the case of bacteria), or can be stimulating, producing development and movement.

He then began to advocate the use of "light baths"

FIG. 5.—Another Portrait of the late Professor Niels Finsen.

as distinct from radiant-heat baths, making use of the cold, so-called "chemical rays."

Finsen next began to experiment with concentrated light, passing the sun's rays through lenses, made in the first instance of glass, and finally of quartz, and

cutting out the heat rays by passing the radiation through clear water; it was, however, found necessary to absorb the red and yellow rays too, so he coloured the water with methylene blue.

He performed some experiments on his wife's ear, and found that there was much greater penetration of the rays if the blood was pressed out of the tissues. He was able to show that no darkening of photographic paper took place—unless the paper was held behind the lobe of an ear which was compressed.

Soon Finsen found that it was impossible to rely on sunlight in northern latitudes, so he began experimenting with arc lamps.

In November 1895 Finsen was allowed by the manager of the Copenhagen central electric power station to experiment in their laboratory. It had been noticed that cases of lupus of the face were invariably a little better during the summer months than in the winter. So Finsen decided to test his theory of positive light treatment in this disease. The treatment of lupus at this time was very unsatisfactory—scraping, the application of caustics, excision with skin grafts, etc., the treatment generally going on for years, and even if healing were effected unsightly scars were left.

Mr Hansen, the manager of the Corporation Electricity Works, was a little doubtful about the propriety of allowing Finsen to actually treat patients at the works; but it happened that he had a friend, a Mr Mogensen, who was suffering from lupus of the face and who had had the disease for eight years; so the latter became Finsen's first lupus patient. Treatment was given from the 20th November 1895 to

March 1896, when the lupus was entirely cured. A very primitive form of arc lamp was used.

About this time some friends were able to get Finsen a small money grant of £65 to help with his

Fig. 6.—Part of the New Finsen Institute Buildings, Strand Boulevard, Copenhagen.

work. He began to feel at this period that he had not very long to live, so he made superhuman efforts to ensure that his ideas should be adapted and put into practical use.

At the time that Engineer Mogensen was receiving arc-light treatment Finsen had a very severe attack

of pneumonia, and this made him all the more anxious to quickly develop his light treatment. Finsen luckily managed to interest several influential men, foremost among them being Mr Hageman and Mr Gorgensen. The help of these two men proved invaluable, so that in October 1896, with the mayor, Mr Borup, as chairman, "Finsen's Medical Light Institute" was formed: "To Institute and Further the Investigations of the Influence of Light on Living Organisms, mainly with the Object of making Practical Use of Light Rays in Medicine."

At first a small building in the Municipal Hospital garden was used. In return for free electric current Finsen promised to give treatment to those patients in the municipal hospital who required it. Only fifteen patients were treated in the first five months that the Institute was opened. In 1897 the total reached seventy-three. Now more than two hundred patients are treated every day.

Finsen published a short paper in December 1896 on "The Use of Concentrated Chemical Light Rays in Medicine." Knowledge of the results which were being obtained by the new cure for lupus soon spread abroad, and in a very short time there were a hundred names on the waiting-list. Queen Alexandra was a very warm supporter of Finsen from the beginning, and she persuaded King Edward and other royalties to visit the Light Institute. In this way Light Treatment Centres were opened in most countries.

Soon the little building in the Municipal Hospital grounds became quite inadequate for the work, and on the 12th August 1901 the present Institute was

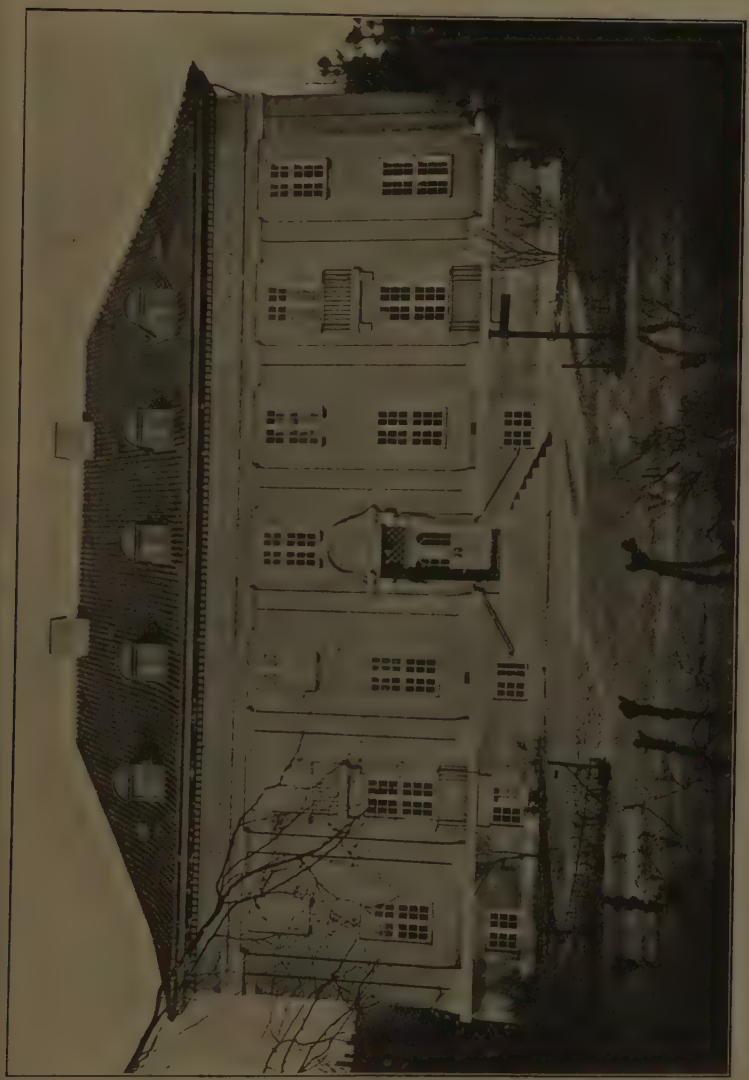


Fig. 7.—Clinic for the Treatment of Internal Diseases at the Finsen Medical Light Institute, Copenhagen.

opened, a Government grant of £12,000 having been obtained. The work rapidly progressed.

On 10th December 1903 Finsen was awarded the Nobel Prize. Most of the summer of 1904 was spent by Finsen in the country: he was very ill, ascites and a very troublesome cough causing him a great deal of distress. He was unable to walk and had to be wheeled about in an invalid-chair by his wife. In September he moved back to Copenhagen and spent a considerable time discussing the affairs of the Institute. On the 24th September he died peacefully, shortly after having said good-bye to his assistants.

Thus Finsen passed at the early age of forty-three; but his spirit still lives.

Quite recently large new hospital buildings have been erected, having nearly two hundred beds for in-patients. The present Finsen Institute buildings are situated on the wide Strand Boulevard, within a stone's-throw of the sea, the new in-patient hospital facing the boulevard. In the grounds are the Radium Institute, the older building for the Finsen local treatment, the Light Baths' building and the hospital for the treatment of internal diseases by actinotherapy.

CHAPTER II

RADIANT ENERGY

The Ether—The Theory of Light—Waves—Sources of Light—Rate of Transmission of Radiant Energy—The Electro-Magnetic Spectrum—Properties of Different Forms of Radiation—Luminescence—Prismatic Analysis—The Solar Spectrum—Recent Discoveries in the Electro-Magnetic Spectrum—Divisions of the Ultra-Violet Region

RADIATION is thought to consist of waves in an all-pervading medium which we know is not air, because the atmosphere extends for a very small distance indeed. The name "ether" has been applied to this elusive something which cannot be described, for the ether is not perceptible to any of our senses. The ether, however, must possess some form of elasticity and resist changes in itself, because this is essential for wave-motion; it must also have inertia or mass, so that it persists in motion. It has always been realized that it is inconceivable that any action could take place through space between two widely separated bodies unless there were some medium of communication between them. There must be something in space which vibrates, and that "something" must extend to the farthest object we can see—the most distant star.

The Theory of Light.—The undulatory theory considers that light is propagated as a succession of waves in the ether, much as waves in water are propagated;

light being defined as an electro-magnetic disturbance of the ether.

We know that water always finds a level, and resists anything which tries to disturb its level. If we depress the surface of the water at one place it becomes heaped up at another and waves are formed. A floating object at sea does not actually move forward with the waves; it is only raised up, pushed forward a little, then let down and pulled back again. The actual particles of water in the wave change from moment to moment. Wave-motion occurs when particles of any material move so that they successively start from and come back again to a given point.

Waves have certain properties in common, which can be most easily realized by considering waves on water.

Wave-length is obtained by measuring the distance between the crests of two waves; amplitude is half the perpendicular distance between the crest and trough of a wave; the frequency is the number of times a second the cycle of movements is repeated at one point. Wave-velocity is obtained by multiplying the wave-length by the wave-frequency.

In all wave-motion the undulations are transverse to the direction of propagation. A wave is always the result of a vibration or an oscillation.

When light is transmitted, just as in the case of waves on water, the oscillations in the ether are transverse to the direction of the motion: all are propagated at the same velocity, but there is a great deal of variation in the number of vibrations per second or frequency, and also in the wave-length.

It seems generally agreed now that light is the result of waves of energy transmitted through the ether and caused by the periodic vibration or rotation of electrons.

Bohr found that the hydrogen atom consists of a nucleus or proton with a negative electron revolving round it like a planet round the sun, in one of several possible orbits, and that every spectral line which a substance is able to emit can be accounted for by the dropping of an electron from one alternate orbit to another.

Electrons taken collectively constitute negative electricity.

Sir Oliver Lodge considers that the physical universe consists of:

(1) Positive electric charges;
(2) Negative electric charges;
(3) The radiation due to sudden movements and re-arrangements among these charged particles.

Electrons and protons arranged in various ways form the atoms of eighty-eight different elements. Radiation is always emitted in jerks, whenever an electron drops nearer the nucleus of an atom.

It has been found that each element has its own characteristic spectrum at a given temperature. If it be visible the wave-lengths indicate the colour, and their amplitude its brightness, or, expressed a little differently, from the colour of the light the rate of vibration of the atom can be determined.

Prismatic analysis proves definitely that every atom of matter has its own definite rate of vibration, just as a bell has. It may emit several colours, or only one,

and the number it emits may depend on the extent to which it is heated. In fact it is now thought that the only way light can be produced is by the vibration of electrons. For instance, every free atom of sodium vibrates in the same way, whatever other element it may be combined with, and whether it exists in the earth, in the sun, or the most distant star. When a metal is heated to incandescence it sets up waves of energy, the waves differing in their frequency of vibration and their wave-length, the frequency increasing proportionately with the decrease in wave-length. A poker can be heated in the fire to redness or with greater temperatures to white heat.

Sources of Light.—The natural sources of light are the sun and the stars—these being bodies undergoing combustion, and therefore self-luminous. The sun is giving off vibrations of the most varied nature and wonderful complexity, all these varying vibrations occurring in the ubiquitous ether. Sir Robert Ball, in his book on the sun, marvels at the wonders of the sun's radiations. To quote his own words :

" When we think that the sun pours forth its radiations with such prodigality that our Earth is only able to intercept the two-thousand-millionth part of the whole ; when we think that the other suns in space, to the number of many millions, are each of them simultaneously filling the ether with their orchestra of vibrations ; when we think of the marvellous delicacy with which that medium transmits all these vibrations, we begin to realize the majesty of the words, ' Let there be Light.' "

Rate of Transmission of Radiant Energy.—It has

been found experimentally that light, in common with other radiant energy, is transmitted through space at approximately 186,326 miles (300,000 kilometres) per second, the velocity being independent of the frequency or the wave-length.

The sun's rays reach the earth in eight minutes.

All electro-magnetic waves travel eight times round the earth in a second.

Astronomers use the term "light-year" to describe the distance travelled by a ray of light in a year, and this is equal to almost six million million miles. Alpha Centauri, the nearest star to the earth, is a distance of four light-years from us, the pole-star is forty-four light-years away, and the five middle stars of the Plough one hundred and eighty light-years away.

Recently a star cloud has been found which is 700,000 light-years away, and in which some of the brightest stars are about 30,000 times as luminous as the sun.

It has been noted that only an infinitesimal amount of radiant energy is perceptible to the human eye, the eye being excited only by an octave of light—that is, the waves at the violet end of the spectrum are pulsating at twice the rate of the waves at the red end. The spectrum extends for many octaves beyond its visible limits.

The Electro-Magnetic Spectrum.—The part of the spectrum which lies beyond the visible violet can be directly observed by the aid of photography, or by means of special fluorescent screens. It is necessary, therefore, to think of a greatly enlarged spectrum —the electro-magnetic spectrum—consisting at one

extremity of the series of Hertzian or wireless waves, sometimes having a wave-length as long as twenty kilometres, passing through several octaves of infra-red rays to the single octave of the visible spectrum; thence through the ultra-violet region to X or Röntgen rays, then the gamma rays given off by radium, with a wave-length of ·1 Å to ·015 Å (Å or an Ångström unit being equal to one ten-millionth part of a millimetre).

Finally, the "ultra gamma" or "cosmic" rays, to which Professor R. A. Millikan has recently drawn attention, and which have been found to have such remarkable properties of penetration; and who can say whether even these form a boundary of the electro-magnetic spectrum?

Luckiesh says: "If a normal spectrum of this entire range of wave-lengths of radiant energy could be produced and the portion of it due to visible radiation —light—were one foot long, the entire spectrum would be several million miles in length."

It has been proved that the velocity of the propagation of electro-magnetic induction through space is the same as that of light.

Hertz produced waves from the oscillatory discharge of a Leyden jar, and showed that these waves which have very long wave-lengths obey the same laws of reflection, refraction and polarization as light waves. They also travel at the same velocity. It is thus considered that radiation is caused by the rapid vibration or oscillation of electric charges within the atomic or molecular structure, the oscillations being continuously maintained at a certain definite frequency corresponding to each wave-length emitted.

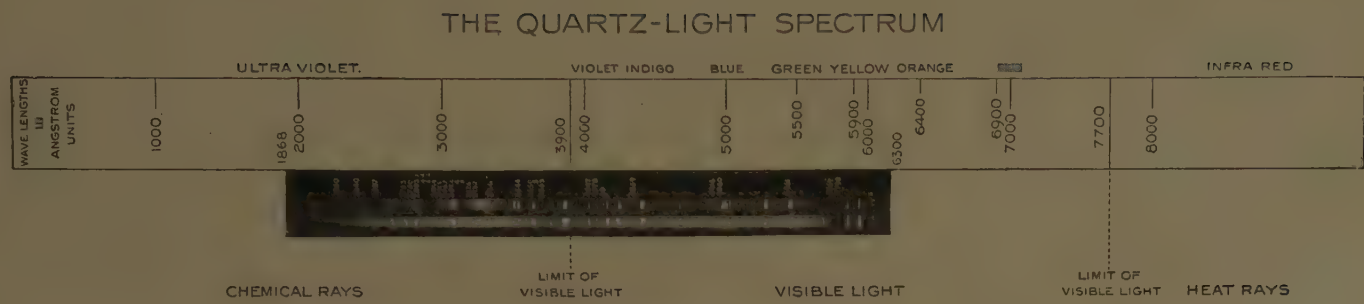


FIG. 8.—The Quartz Mercury Vapour Lamp Spectrum.

X-rays, like light, are considered to be ether waves, of very short wave-length.

Heat obeys the same laws as light. It is reflected, refracted, and the law of inverse squares also applies. In a uniform medium light travels in straight lines. When an eclipse occurs light and heat are cut off at the same time; hence both must travel at the same enormous speed.

The ultra-violet spectrum is found to be continuous with the visible spectrum. Ultra-violet radiations have been found to be reflected and refracted according to the usual laws. They can be caused to interfere, and can be polarized by crystals—for instance, tourmaline—in exactly the same way as ordinary light.

When waves are absorbed by a blackened surface their energy is converted into molecular energy or heat. The molecules of the absorbing substance being set in motion they in their turn become sources of disturbance in the ether, and generate waves in the latter. Lord Kelvin estimated that every square foot of the sun's surface radiates energy at the rate of 7000 horse-power.

Luminescence.—Generally, when light is absorbed by a substance it is converted into heat, but sometimes luminescence results—that is, there is an emission of light from the absorbing body. Luminescence includes photoluminescence, which can again be divided into fluorescence and phosphorescence, in both of which cases light of a certain wave-length falling on a substance results in the emission of light of a longer wave-length. If the luminescence exists only when the exciting rays are acting, it is called fluorescence. If it

continues after the stimulus has ceased it is called phosphorescence. These phenomena are probably due to the separation and recombination of electrons from their parent atoms. Janet Clark ably describes the reaction as follows:

"In true photo-electric effect the electrons are lost from the substance; in fluorescence they return to their original atom; in photo-chemical reactions they attach themselves to some other atom or group of atoms."

X-rays and ultra-violet radiations passing through the air cause the latter to conduct electricity, the ionizing effect of the X-rays, however, being much greater than that of the ultra-violet rays.

Prismatic Analysis.—In 1801 Ritter and Wollaston showed that when sunlight is passed through a prism the dark area beyond the violet of the resultant spectrum contains rays which are capable of blackening silver chloride.

Prisms in general have the effect of breaking up or dispersing a beam of light projected on them. There is comparatively slight refraction with the visible spectrum, but considerable with the ultra-violet portion. In the region 2000 Å the separation corresponding to a given difference of wave-length is ten times as great as in the region 4000 Å. This renders the study of ultra-violet radiation a matter of greater ease than that of the regions of longer wave-lengths. A point, however, is reached when the material of the prism, even though it may be of quartz or fluorite, absorbs the radiation projected on to it. Another means of studying the shorter rays has to be adopted,

and the diffraction grating is made use of. It consists essentially of a thin sheet of quartz or fluorite on which a large number of fine lines have been ruled very closely together, the lines being parallel and equidistant.

Obviously it is a matter of physical impossibility to rule lines sufficiently near to each other when a certain point is reached, but nature has provided such an apparatus in certain crystals (a crystal consisting of layers arranged one behind the other containing regular assemblages). By this means the wave-lengths of X-rays have been measured and found to vary from 12 Å to ·15 Å in length. The shorter the wave-length the greater its penetrative power or hardness.

The Solar Spectrum can be divided roughly into visible and invisible portions. The visible spectrum is composed of the seven well-known colours—red, orange, yellow, green, blue, indigo and violet—one colour merging gradually into the next. Each of the colours is a movement of the ether, with its own average wave-length—namely,

Colour	*Wave-Lengths* Å	*Average Frequency* Million Millions per sec.
Red	7700–6200	375
Orange	6200–5900	541
Yellow	5900–5500	571
Green	5500–4900	595
Blue and indigo	4900–4300	645
Violet	4300–3900	750

The visible spectrum thus extends from 7700 Å to 3900 Å.

In the solar spectrum Fraunhofer's lines are present. These correspond to radiations emanating from the central mass of the sun, but absorbed by its cooler periphery. In the case of light it is known that many of the dark lines in the absorption spectrum of a body are in the same position as the bright lines in its emission spectrum; in other words, a body under suitable conditions—*e.g.* when cooling—is capable of absorbing strongly its characteristic light radiations.

With X-rays the contrary is the case, an element being especially transparent to its characteristic X-radiations. "The sodium atom contains systems of electrons which, when suitably excited, give out light of the frequency corresponding to the sodium lines. To use an analogy from sound, or from wireless telegraphy, the sodium atom is tuned to this frequency. It will, therefore, begin to vibrate violently if oscillations of this period fall upon it—in doing so it abstracts the energy of the radiation in tune with itself, so that the latter is very rapidly absorbed, while light with frequency remote from this passes on almost unaffected. Thus after passing through a very small thickness of material the light is robbed of all the constituents which have frequencies corresponding to those of the radiating systems within it. Hence all the electronic systems which have natural periods falling within the limits of the visible spectrum must produce a dark band when white light is passed through." Thus does Crowther describe the phenomenon in his recent book on *Molecular Physics*.

Experiments have shown that for an atom to emit its characteristic spectrum it is necessary that it

should be in a region of intense ionization or recombination. It seems that nothing short of driving an electron into or out of the atom will suffice to set in vibration the light-emitting systems of electrons. In 1800 Herschel repeated Newton's classical experiment of passing a beam of light through a prism and thus breaking it up into its component parts. He placed a thermometer with a blackened bulb in various parts of the spectrum, and found that beyond the red it showed a rise of several degrees when the eye could see nothing. He thus demonstrated the presence of infra-red rays. Recently the area has been extended some nine and a half octaves by the use of rock salt and sylvine prisms—that is, up to the Hertzian system.

The solar spectrum, extending from 2900 Å to 20 μ (μ being one-thousandth part of a millimetre), contains about six octaves of infra-red rays, one of luminous and about half-an-octave of ultra-violet rays. The spectrum of the infra-red region has been mapped out by Professor Langley with his bolometer —an extremely sensitive instrument which can show a rise in temperature amounting to no more than one-hundred-millionth part of a degree centigrade. What would be a dark band in the spectrum, could we but see it with our eyes, would fail to heat the sensitive platinum strip of the bolometer, and the galvanometric deflection would be correspondingly diminished or reduced to zero. A bright band in the spectrum would, of course, have an exactly contrary effect.

Ultra-violet radiation can be considered as formed of invisible rays whose frequencies are greater than

those of the visible spectrum. By means of quartz prisms and lenses the region between 3900 Å and 1850 Å has been photographically recorded. Schumann mapped out the area from 1850 Å to 1230 Å by using lenses and prisms made of fluorite instead of quartz (as quartz absorbs practically all radiations having wave-lengths less than 1850 Å), and also by using a vacuum spectroscope to prevent air absorption, as below 1700 Å atmospheric air becomes strongly absorbent.

FIG. 9.—Spectrogram showing part of Visible and Ultra-Violet Regions.

Lyman, in fact, states that absorption of the air begins to manifest itself in the near ultra-violet, but becomes critical only about wave-length 2000 Å.

Recent Discoveries in the Electro-Magnetic Spectrum.—Recently Lyman, by using powerful electric discharges in a helium vacuum, has been able to reach wave-length 510 Å. Millikan, by using electrodes, of non-fusible material, separated by a very small space, and employing a huge potential of 100,000 volts, has reached wave-length 202 Å. Holweck, with slow cathode rays, has produced X-rays having a wave-length of 500 Å, so that the gap which formerly separated X-rays from ultra-violet has now been bridged.

The doctor using ultra-violet radiations therapeutically is concerned, however, only with the area

Table showing the Properties of the Different Rays of the Electro-Magnetic Spectrum

	Hertzian Waves	Infra-Red Rays	Visible Rays	Ultra-Violet Rays	X-Rays	Gamma Rays
Generation	Oscillating discharge of condensors, resonators, etc.	Heat radiations from hot bodies	Radiated from hot bodies and emitted by ionized gases	Emitted from very hot bodies, and also by ionized gases	Emitted by sudden stoppage of fast-moving electrons	Emitted when atomic nuclei disintegrate
Generation in Medicine	Discharge of condensors with spark gap, etc.	Electric radiator, carbon filament lamp, arc	Carbon filament lamp; arc	Mercury vapour lamp; arc	Spark coil or transformer	Radium with thick filter
Detection	Coherer	Bolometer; rise in temperature of receiving body	Photography; produce sensation of light; certain chemical actions; photo-electric effect	Photography; phosphorescent effects; chemical effects; ionization; photo-electric effect	Photography; phosphorescence; chemical action; ionization	No effect with fluorescent screen; phosphorescence; chemical action very vigorous; discharge of gold-leaf electroscope
Reflection	By sheets of metal	By polished metallic surfaces	By ordinary mirror, etc.	Especially by silicon, nickel and magnalium	No ordinary reflection	?
Refraction	By large prisms of pitch	By rock salt prisms	By glass prisms, etc.	By quartz or fluorite prisms	No ordinary reflection	?
Diffraction	Yes	With coarsely ruled grating	With ruled grating on glass or metal	With finely ruled grating	Yes, by crystals	?
Penetration	Penetrating	Slight penetration rapidly absorbed by water	Slight penetration of body; more than infra-red; red rays most	Very slight penetration of most substances except air, quartz, fluorite and water	Penetrates all matter to a greater or less extent	More penetrating than even X-rays

Selective Absorption	Metals containing free electrons	Water	Hæmoglobin	Albuminous substances, particularly tyrosin and phenylalanin	Molecules of heavy atomic weight	Molecules of heavy atomic weight
Wave-Length	Several kilometres to 1,000,000 Å	1,000,000 Å to 7700 Å	7700 Å to 3900 Å	3900 Å to 136 Å	1019 Å to ·15 Å	·1 Å to ·015 Å
Velocity	← 186,326 miles per second →					
Medical Applications	High frequency; diathermy	Thermotherapy; calorotherapy	Phototherapy	Actinotherapy	Roentgen therapy	Radium therapy
Action on Skin, etc.	With diathermy through heating	Immediate hyperæmia	No hyperæmia if infra-red rays are removed	Hyperæmia after a latent period of a few hours	Hyperæmia after a latent period of many days	Very lasting hyperæmia after latent period
Effect with Overdosage	Destruction of tissue	Destruction of tissue with charring	Superficial effect; no destruction of tissue	Superficial effect only	Destruction of tissue	Destruction of tissue
Rate of Ordinary Reaction	Immediate	Immediate and soon fading	Immediate and soon fading	After latent period of several hours	After latent period of several weeks	After long latent period, reaction very lasting
Action on Body	Vaso-dilatation and heating	Hyperæmia; elevation of temperature and decongestive effect	Increases hæmoglobin	General tonic effect, improved nervous tone, and calcium and phosphorus absorption, etc.	Local action; destruction of young active cells	
Effect on Bacteria	?	Abiotic above certain temperatures	None, unless certain sensitizers are added, such as eosin, erythrosin	Abiotic, also destroying most toxins and antitoxins	None	?

between 3900 Å and 1850 Å. Browning and Russ have shown that from the clinical point of view there are two distinct regions of ultra-violet radiation—the first extending from 3800 Å to 2960 Å, being rays which are capable of penetrating a considerable depth of human skin, but having no bactericidal effect; and secondly, those extending from 2960 Å to 2100 Å, which have a strong germicidal effect, but are not capable of penetrating more than one-tenth mm. of skin. The maximum abiotic effect is produced by rays between 2800 Å and 2540 Å.

The following table gives the different wave-lengths of the complete spectrum:

Gamma rays of radium .	·1 Å to ·015 Å
X-rays	·1019 Å to ·15 Å
(Those generally used for medical purposes having a wave-length varying between 1 Å and 0·15 Å)	
Ultra-violet . . .	136 Å to 3900 Å
Visible spectrum . . .	3900 Å to 7700 Å
Infra-red	7700 Å to 5,000,000 Å
Hertzian oscillations:	5,000,000 Å to several kilometres

Laue has proved that crystals will produce interference effects with X-rays similar to those produced with diffraction gratings in the case of light waves; and Professor Bragg has been able to focus X-rays with bent sheets of mica. Curiously, Röntgen rays have little or no effect on bacteria, and in this respect show a marked contrast to ultra-violet rays, certain wave-lengths of which, as already stated, have a most marked bactericidal action.

CHAPTER III

NATURAL ULTRA-VIOLET RADIATION

Comparison of Natural and Artificial Radiation—The Solar Spectrum—Influence of Altitude, Time of Day and the Seasons—The Technique of Heliotherapy—Dosage—Local Heliotherapy

THE natural source of ultra-violet radiation is sunlight, which is the most powerful form of radiation known. It is very difficult to realize that of the total solar radiation only the $\frac{1}{2,000,000,000}$th part is intercepted by the earth, and that only $\frac{6}{10}$ths of this amount passes through the earth's atmosphere.

The intrinsic brilliancy of the sun's surface has been calculated to be 1000 candles per square millimetre, while an arc lamp has only a brilliancy of 170 candles for the same area. Solar rays are parallel, while artificially produced rays always diverge from their source unless they are passed through special lenses.

There is great diversity of opinion as to whether natural sunlight or artificially produced rays are of the greater therapeutic value. Dr Rollier is strongly in favour of the former, and we all realize that sunlight, together with pure, fresh, dry air, free from dirt and smoke, such as can be obtained at Alpine resorts, is better than doses of artificially produced rays administered in hot rooms in the centre of our smoky cities. In Switzerland at altitudes over 5000

feet the supply of sunlight is very constant, whereas in England the sun appears very erratically, and when it does its actinic value varies almost from minute to minute, making dosage difficult and regular courses

FIG. 10.—Children Patients at Dr Rollier's Clinic, Leysin, playing in the Snow.

impossible, so one must often fall back on "artificial sunshine."

Some phototherapists hold that certain rays from the sun are unnecessary, and even harmful, for therapeutic purposes, and these are not present in artificial actinotherapy.

"Sun and ultra-violet rays bear much the same

relation to one another as crude drugs do to their synthetically prepared chemical substitutes" is a quotation from Rollier's book on heliotherapy.

An examination of statistics of various cases of tuberculosis treated by heliotherapy at Leysin, and by carbon arc radiation at the Finsen Institute, Copenhagen, reveals the surprising fact that the results obtained by the two forms of treatment are almost identical, and in some cases the Finsen results are even better than those obtained under the ideal conditions of the Alps. This is even more wonderful when one realizes that the patients at the Finsen Institute are out-patients, who return to their none too healthy homes after treatment, and who obtain a minimum of fresh air or sunshine.

TABLE SHOWING PERCENTAGE OF RADIATIONS GIVEN OFF BY VARIOUS SOURCES (*After* PACINI)

Source	*Infra-Red*	*Light*	*Ultra-Violet*
1. Mercury Vapour . .	52%	20%	28%
2. Sunlight . . .	80%	13%	7%
3. Arc Lamps (such as Carbon)	85%	10%	5%
4. Incandescent Lamps .	93%	6%	1%

The limits of the solar spectrum are influenced by the seasons, by the clearness of the atmosphere, by the height of the sun above the horizon—*i.e.* the time of day—and by altitude, but it has been found that the last-mentioned has very little effect on the range

[By permission of Sir Henry Gauvain.

FIG. 11.—Sun Treatment on the Beach at Hayling Island.

of the solar spectrum; however, the spectral range decreases very considerably the lower the sun is in the heavens—that is, with the longer path through the earth's atmosphere that the radiation has to traverse. Red skies at sunrise and sunset prove that the atmosphere absorbs rays of short wave-length.

The sun's rays reach their maximum intensity at about 1 P.M., and not at noon, as might have been expected; the greatest intensity of rays of short wave-lengths occurs at the same time.

Seasonal influences affect both the sun's spectral range and the intensity of the solar radiation.

It is in the month of July that the maximum range of the spectrum is usually found, while in winter the smallest amount of ultra-violet radiation is present. In winter the intensity of ultra-violet radiation at high altitudes varies considerably from that found at low; the greatest amount of both ultra-violet and calorific radiation being found at high altitudes; in summer this big difference between high and low altitudes does not exist.

From May to September the intensity of the ultra-violet radiation remains fairly constant, but from October to April sudden variations of considerable extent are commonly found, variations which are often rather inexplicable. With the exception of one month (July) the intensity of the calorific radiations is always greater than that of the ultra-violet.

Diffuse light also plays its part in heliotherapy, as it contains a larger proportion of ultra-violet rays than one would imagine, as rays of short wave-length are more easily diffused than rays of longer wave-length.

Small particles of dust, water, vapour, etc., are responsible for the diffusion of light; therefore it is obvious that the greater the thickness of atmosphere which the rays must traverse the greater will be the resulting diffusion. Hence the intensity of diffused light is greater at low levels than at high, and at those parts of the day when the sun is lowest in the heavens. The intensity is also greater in winter than in summer.

As one would expect, reflection increases the intensity of diffused light, and it is found to be greatest near large expanses of water or above stretches of snow.

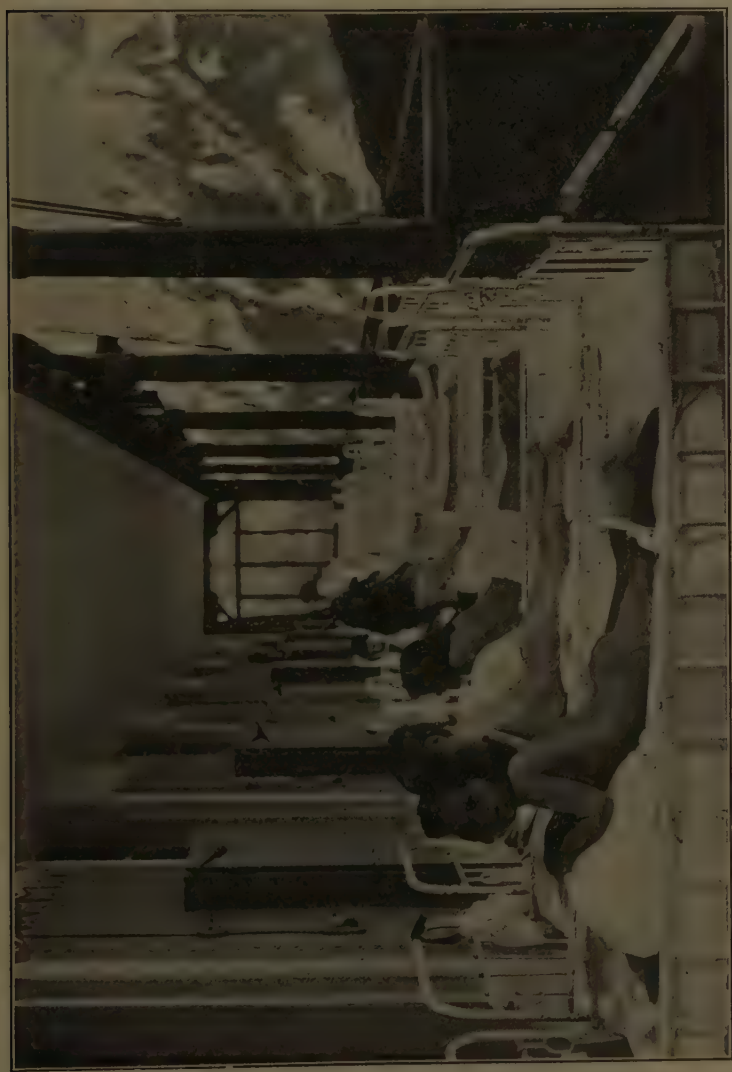
Heliotherapy is the graduated exposure of the whole or part of the body to the sun's rays.

The practice, as we have already stated, is by no means new, the Greeks and Romans knowing and making good use of the salutary effects of solar radiation.

When possible, the whole body, with the exception of the head, should be exposed to sunlight, preferably out-of-doors, but if this is not feasible the patient should be placed in front of an open window, or a closed window glazed with "Vitaglass," which allows the free passage of all the natural ultra-violet rays.

The time of day chosen for sun baths varies with the seasons, and should be when the temperature of the surrounding air is favourable—that is, when the temperature taken in the shade is about 46° F. In winter some time between 10 A.M. and 3 P.M. will generally suffice, and in summer between 6 A.M. and 11 A.M. and between 3 P.M. and 5 P.M.

The temperature of the surrounding air which



[Dr A. Rollier

By permission of]

FIG. 12.—A Sun Gallery at Leysin for the Treatment of Potts' Disease.

is comfortable to the patient varies greatly with different subjects; the greatest heat can be tolerated by those who are used to the treatment, and also by those who are young and fairly strong.

The same methods—which will be described later—can be used for the measurement of the intensity of the solar rays as are used for radiation from artificial sources.

Great care must be taken to avoid over-exposure, especially at the beginning of treatment, with delicate patients and those suffering from tuberculous lesions: any rise in temperature or pulse rate, or signs of nervous irritation after exposure, should lead to the exposure being decreased, or the treatment discontinued, according to the severity of the symptoms.

It is not customary to expose the whole body at the beginning of treatment, only a small surface being uncovered on the first day, and this area is increased daily until the whole body is being irradiated.

The head should always be shaded and dark glasses worn to protect the eyes.

If the patient is very weak or sensitive, eight to ten days are allowed to elapse before the whole body is exposed, and great care is taken to record the temperature and pulse. If, on the other hand, the patient tolerates irradiation well, pigments quickly and is fairly strong, the process may be accelerated, and the whole body exposed after three or four days.

Dr Rollier's method of fractional exposure is very advantageous and is widely used.

At the first application the feet alone are exposed, on three separate occasions during the day, for five

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FIG. 13.—A Solarium at Lord Mayor Treloar's Cripples' Hospital, Alton.

minutes. At the second treatment the feet and legs are exposed for five minutes, then the legs are covered and the feet exposed for another five minutes. On the following day, in the same way, the feet are exposed for fifteen minutes, the legs for ten minutes and the thighs for five minutes. On the fourth day the exposure of the feet is increased to twenty minutes, the legs to fifteen minutes, the thighs ten minutes and the abdomen five minutes; and in the same way the thorax is included on the fifth day, unless the patient is suffering from phthisis or heart trouble. It is unwise to expose the chest for about a month.

The exposure of the body is then increased gradually, by five minutes per day, until a maximum of three to four hours is reached.

As already mentioned, this procedure may be modified according to the susceptibility of the patient, but when marked pigmentation is established there is no further fear of over-exposure.

Patients tolerate two or three short exposures with rest-intervals much better than a single long exposure.

Where practicable, a tepid bath or douche is beneficial after insolation, especially if there has been profuse sweating, but if this is not possible the patient should rest for some minutes.

A patient should be immediately covered with rugs if he feels too cold during treatment.

Any ulcers or sinuses should be left exposed.

It should be remembered that brilliant sunshine is not essential for heliotherapy, as diffused rays play an important part, especially near the sea, or near snow, where reflection increases their effect.

FIG. 14.—Some of Dr Rollier's Patients undergoing the Natural Sunshine Cure at Leysin, in the Vaudois Alps (from *Modern Science*).

If treatment is interrupted by bad weather, or from some other cause, it should be recommenced with a smaller dose.

Patients who are sent to high Alpine sanatoria should not be insolated until they have become accustomed to the altitude and the air; marked disturbances, which generally pass off in two or three days, are often noticed; so that exposure to the powerful sunlight must be undertaken only with great caution.

The effects of exposure to sunlight are the same as those of exposure to rays from artificial sources.

During insolation the pulse and respirations are slightly increased. After a long exposure the temperature of the body may be slightly raised, but it returns to normal from a half to one hour after the cessation of treatment.

Perspiration is profuse if the rays are very hot, and particularly if the temperature of the surrounding air is high and the exposure is long.

The patient experiences a feeling of well-being after a sunbath unless it has been too prolonged. After a latent period of several hours erythema becomes marked, and blisters may form if the patient is too sensitive or the exposure has been too long. This condition lasts for two or three days, and is followed by pigmentation. When the latter is well established there is no fear of excessive reaction.

The various general changes which accompany irradiation are identical with those occurring in artificial radiation, and will be more fully discussed in the chapter dealing with biological changes.

In local heliotherapy Finsen used quartz lenses to

concentrate the rays on lupus lesions, but found the method too uncertain.

Dr Sorgo has designed a simple apparatus for direct insolation of the larynx, which will be described later.

Clothes made of cellulose acetate are partly permeable to the ultra-violet rays, and their use thus confers certain advantages.

CHAPTER IV

CARBON, TUNGSTEN AND IRON ARC LAMPS

Incandescent Lamps and Light Baths—Classification of Arc Lamps—The Arc—Short-Flame and Long-Flame Arcs—Regulation of an Arc—Carbons—Open Arc Lamps—Enclosed Arc Lamps—Special Types of Arc Lamp—Tungsten Arc Lamps—The Iron Arc Lamp

As has been mentioned previously, it is very difficult and almost impossible to practise heliotherapy in this country, owing to its low altitudes and its climatic conditions. The moisture-laden atmosphere and the smoky air filter out practically all the therapeutic rays of the sun, particularly in our large cities, and especially in winter, so that the sunlight we get is very often lacking in these rays. Consequently we must rely on artificial light for our phototherapy, some form of electric arc or incandescent lamp being generally used.

Incandescent Lamps and Light Baths.—The incandescent electric lamp is very rich in visible and heat rays, but the ultra-violet rays are almost completely cut off by the glass bulb.

These light baths, however, applied either locally or to the whole body, are of great value in many disorders such as neuritis, rheumatic conditions such as lumbago, fibrositis, myalgia, torticollis, gout, rheumatoid arthritis, chronic nephritis and early arterio-sclerosis.

By means of these baths the temperature of the skin can be raised to an intense heat (locally to 260° C. and generally to 204·4° C.) without danger. This degree of heat results in dilatation of the cutaneous

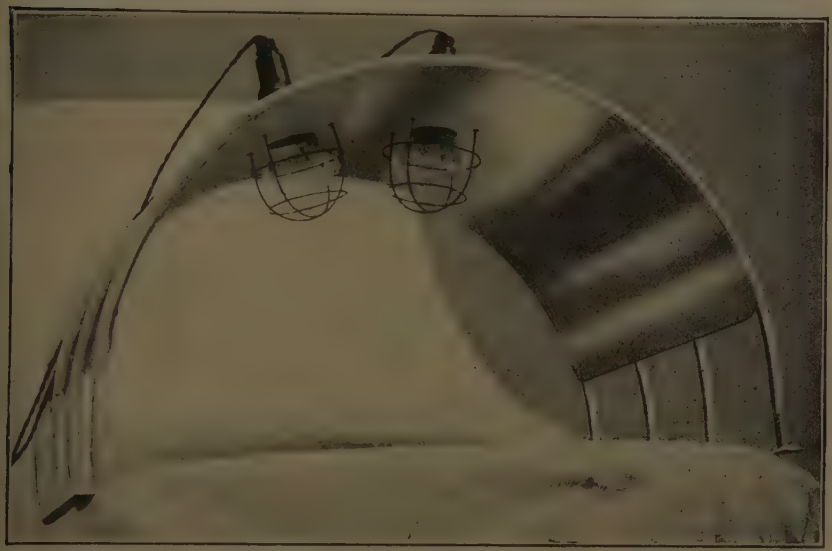


FIG. 15.—The "Ulvira" Apparatus showing the two Quartz Globes fitted with Tungsten Filaments which form a weak source of Ultra-Violet Radiation. (Siebe, Gorman & Co.)

arterioles, and stimulation of the sweat glands. Internal congestion is relieved, pain lessened, and a feeling of well-being and comfort results. An increase in metabolism and the hæmoglobin content of the blood can also be demonstrated. If, however, a quartz bulb is substituted for the glass one of an incandescent electric lamp it forms a weak source of ultra-violet rays, and may be beneficial in some cases if several lamps are burned continuously in as close proximity to the nude body of the patient as comfort allows.

The "Ulvira" apparatus manufactured by Siebe, Gorman & Co. is of such a type.

Ultra-violet rays, or actinic rays as they are often termed, are much more effective as therapeutic agents than are the visible and infra-red, or heat, rays, and their chief sources of production are electric arc lamps. They may also be generated by the spark discharge of Leyden jars or spark coils, but not in sufficient volume for therapeutic purposes.

If the reader finds the chapters describing apparatus rather tedious he is advised to pass them over—if his interest begins to flag. The authors, however, feel that it is very desirable that the various types of apparatus should be described, because many different lamps are being used to-day, and it is only reasonable that the reader should find his own lamp at least mentioned, and this is not possible when the products of only one particular firm are discussed.

Arc lamps may be divided into two main groups:

1. Open arcs.
2. Enclosed arcs.

Arcs can also be:

(*a*) Hand-fed.
(*b*) Automatically regulated.

Again they can be:

(*a*) Air-cooled $\begin{cases} \text{non-mechanically.} \\ \text{mechanically.} \end{cases}$
(*b*) Water-cooled.

Open arc lamps usually have their electrodes made of carbon, pure or modified; but various metals may

be used—such as tungsten, iron, aluminium, cadmium, silicon, etc.

Carbon arc lamps are generally of the open type, but the "Quain Quartz Arc" and the "Heliol" lamp are two examples of enclosed carbon arcs. Quartz mercury vapour lamps are, however, the commonest type of closed arc.

Most carbon arcs are automatically fed, while hand-feeding is generally the rule with tungsten lamps. General treatment lamps are usually air-cooled, while it is customary to use water-cooled lamps for local treatment.

The Arc

A space filled with air or some other gas can be bridged by an electric discharge in one of three ways:

1. By a glow discharge, as seen in the "Neon" lamp.
2. By an electric spark: the induction coil furnishes a familiar example.
3. By an electric arc.

When two electrodes, charged with a current of sufficient strength and maintained at different potentials, are brought together the points in contact immediately become extremely hot, and some of the carbon is volatilized; if the electrodes are then slightly separated the carbon vapour conducts the current from one electrode to the other, an intense illumination results and an arc is formed.

Sir Humphry Davy first discovered the phenomenon in 1801. In 1808 he exhibited an electric arc produced by a battery of 2000 cells at the Royal Institution.

In the electric arc a flame of luminous vapour fills the space between the electrodes and their ends become incandescent. When the electrodes are in the horizontal position the flame is arch-shaped, hence the name "arc."

The colour of the arc flame depends entirely on the electrodes used; pure carbons generally give a white flame, while different metals produce green, blue or violet-coloured flames. In the direct-current arc the tip of the positive carbon becomes extremely hot, reaching a temperature of 3500° C.

A cup-shaped depression forms at its extremity, known as the crater. The negative carbon becomes sharply pointed.

The positive carbon is generally made thicker than the negative, because in the open arc it would burn away almost twice as quickly as the negative if the two carbons were made the same size.

In the direct-current open arc 85 per cent. of the radiation is from the brightly incandescent positive crater, 10 per cent. from the negative carbon, and only 5 per cent. from the flame of the arc itself.

The carbon arc flame consists of an inner violet band formed of carbon vapour surrounded by an outer yellow aureole.

The maximum radiation is given off from the positive crater at an angle of about forty to fifty degrees to the negative carbon.

The two carbons are generally arranged co-axially in the vertical position when the continuous current is being employed, the positive being uppermost. A thin negative carbon offers less obstruction to the

radiation, but if it is made too thin the incandescent area is not confined to the end of the carbon, but spreads up the shaft ; and we have noticed that when this happens very fine flakes of carbon are gradually cast off from the shaft of the negative electrode, and

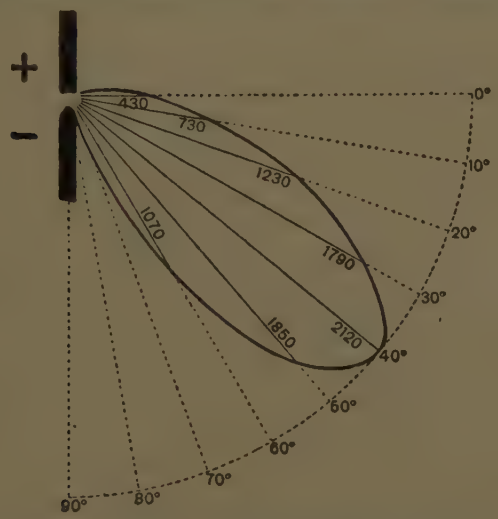


FIG. 16.—Curve showing the Distribution of Radiation from a Direct-Current Short-Flame Arc. The figures printed on the radial lines represent the candle-power in different directions. (Fleming.)

it becomes completely disintegrated and has to be replaced. At the same time the arc becomes unstable and begins to hiss. This is probably due to the crater overlapping the end of the carbon and thus allowing free access of air to the crater. When hissing occurs the arc voltage suddenly falls.

In some types of lamp the carbons are inclined at various angles, and may even be arranged parallel to each other.

The alternating-current arc is not so satisfactory for medical purposes as the direct-current arc, because the emission of radiation is so different. In the alternating-current arc the polarity of the two carbons varies very rapidly, so that each in turn becomes the crater.

When the carbons are in the co-axial position as much radiation is given off above a horizontal line drawn through the centre of the arc as below it. The alternating-current carbons are made the same thickness, as they each burn away at the same rate.

Open arcs burn freely in the air, as they are not surrounded by any containing vessel.

The air has only limited access to an enclosed arc. The encircling tubes or globes are generally made of "Uviol" glass, "Vitreosil" or clear quartz, but "Vitaglass" globes are now being made also.

If the air has no access at all to an arc the globe soon becomes blackened by carbon deposits, but the admission of a regulated amount of air ensures perfect combustion; curiously, the carbons burn with flat ends, no crater or point being formed.

The advantages of the enclosed arc are that:

(1) The carbons last for a much longer time than do open arc carbons;

(2) If special carbons are used no unpleasant fumes are given off, such as are emitted by the same carbons in the open arc.

The rays of greatest power are emitted from the enclosed arc in a horizontal direction. The principal disadvantage is that a certain amount of the radiation is cut off by the globe.

Short-Flame and Long-Flame Arcs.—These terms are relative; there is no definite point at which a short-flame arc becomes a long-flame one. The longer the arc the shallower the crater, and if the length of the flame is greater than the diameter of the positive carbon there is practically no depression at all.

Special impregnated or chemical carbons must be used for the production of the long-flame arc. The white-flame arc is produced by carbons impregnated with barium salts; strontium colours the arc flame red and calcium fluoride yellow. Sixty-five per cent. of the radiation from the flame arc comes from the flame itself—the radiation is directed horizontally outwards, but the greatest intensity is just below the crater.

An increase in voltage allows lengthening of the arc. Taylor and Griffith have found that when the arc length does not exceed twelve millimetres, and when similar electrodes and the same number of watts (volts × ampères) are used, more ultra-violet rays are given off by the long flame than by the short, and also under similar conditions the long-flame-arc ultra-violet emission is greater than that of a group of several arcs in series; but the total radiation (infra-red, visible and ultra-violet rays) is greater in the composite arc, and the heating effect is therefore more intense.

When the length of the arc is greater than twelve millimetres Angus's law holds good, and for the same amount of power consumed the short-flame arc and the long give off an equal amount of ultra-violet rays. So that when the lamps are used from the main

without a motor-transformer it is more economical to use long-flame arcs, as less current is wasted in the resistance.

The carbons of the long-flame arc can be arranged co-axially, or else inclined at such an angle as to be almost parallel, as in the "Jupiter" lamp.

Regulation of an Arc.—Arcs may be (*a*) hand-fed or (*b*) automatically regulated.

(*a*) Hand-feed arcs are satisfactory only when very short exposures are given; automatic feeding is necessary for long exposures.

(*b*) Automatic feeding of an arc requires two essential factors:

(1) That when the current is switched on the carbons are momentarily brought together, and then automatically separated to a required distance;

(2) That this distance is maintained as the carbons burn away.

In the simplest form of automatically regulated arc the positive carbon is attached to a T-shaped iron rod, the two free limbs of which are inserted into two hollow cylinders. One cylinder is wound round with thick insulated wire and the other with thin wire. The coil with the thick wire is called the series coil, and it is inserted into the line carrying the current to the positive carbon, while the spiral of thin wire is called the shunt coil, and it joins the positive to the negative wire. When the current is switched on the carbons which had previously been in contact are separated by the attraction the series coil exercises on the iron rod, and the arc is struck. As the carbons

burn away the length of the arc flame increases, and the current across the arc becomes weaker, so that more current passes through the shunt coil, which then acts on the iron rod and draws the carbons nearer together. The space between the carbons is therefore automatically regulated and kept fairly constant.

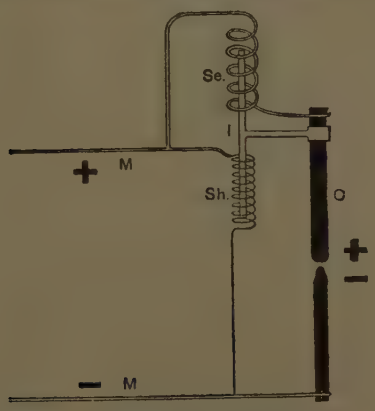
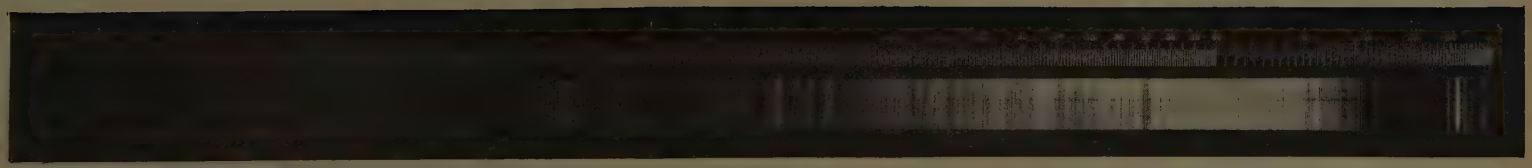


FIG. 17.—Diagram of Shunt and Series Coil Arc Mechanism. (Fleming.)
MM are the two Electric Supply Mains; Se., the Series Coil; Sh., the Shunt Coil; I, the Iron Core; and C, the Carbons.

Carbons.—In arc lamps the carbons are of great importance, and special care is needed in their manufacture, particular attention being paid to their composition, density and electrical resistance, otherwise the efficiency of the arc may be impaired.

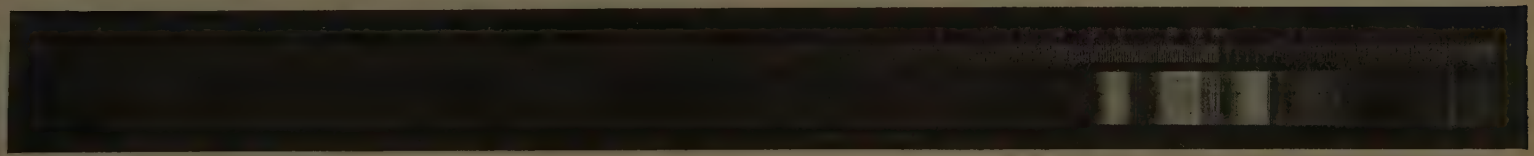
Carbons are usually made by mixing ground coke and lampblack with coal-tar or syrup, forming a stiff paste, which is then submitted to hydraulic pressure, rods being formed; these are afterwards baked in a special furnace.

A



"Westminster" Sun-Ray Arc, with white-flame electrodes, 92 volts across arc, 30 ampères, electrodes $2\frac{1}{4}$ in. apart.

B



Open Type Sun-Ray Arc, with ordinary electrodes, 48 volts across arc, 48 ampères, electrodes $\frac{3}{8}$ in. apart.

C

"Westminster" Sun-Ray Arc, with tungsten-cored electrodes, 73 volts across arc, 32 ampères, electrodes $1\frac{1}{8}$ in apart.

FIG. 18.—Arc Lamp Spectra.

Carbon is specially adapted for use as an electrode because its oxide is a gas, and therefore does not form a deposit round the arc; as it is a relatively poor conductor of heat and electricity the crater is raised to a high temperature; also, compared with metals, carbon is easily disintegrated, and gives a longer arc for a given difference in potential between the two poles.

To begin a true electric arc carbon requires a pressure of thirty-five volts or more; iron, twenty-five volts, and copper, twenty-three volts. The more infusible material an electrode is made of the greater the difference of temperature of the two poles.

Carbons may be (*a*) cored; (*b*) non-cored.

The central core may be made of a less dense form of carbon, so that the crater tends to keep to the easily volatilized central area. Metallic cores, such as iron, aluminium, molybdenum or tungsten, may, however, be used, and the polymetallic carbons are cored with a mixture of several metallic salts, principally of magnesium, aluminium and calcium. Oswald has shown that when large cores are used there is a bigger proportion of the total radiation in the ultra-violet region, because the incandescent area of pure carbon then becomes smaller and less infra-red rays are given off. Carbons may also be impregnated with various salts of the alkalies and alkaline earths, such as fluorides, silicates, borates and phosphates.

It is also possible to modify the radiation given off by using different types of carbon for each of the electrodes.

Although not so rich as the tungsten and mercury

vapour arcs in far ultra-violet rays, the carbon arc light has great penetrating power, and emits intense

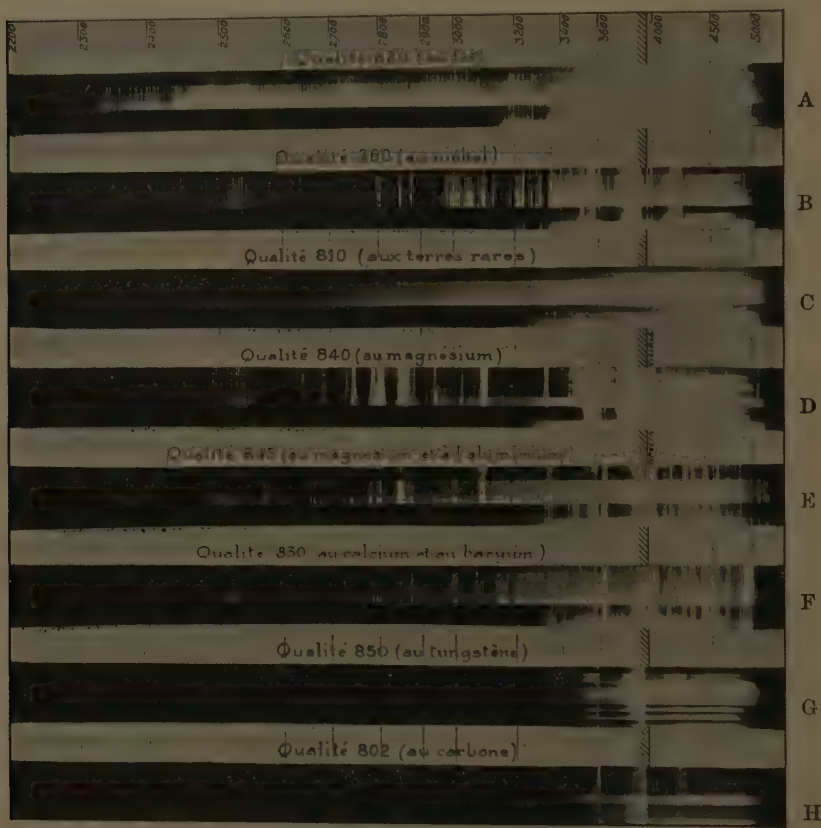


FIG. 19.—Spectrographs of Different-cored Carbons. (Oswald.)
A, Iron-cored; B, Cored with Nickel; C, Cored with Rarer Alkaline Earths; D, Cored with Magnesium; E, Magnesium and Aluminium Cores; F, Calcium and Barium Cores; G, Tungsten-cored; H, Plain Carbon.

radiations in the near ultra-violet region. Direct current is always preferable for use with carbon arc lamps.

A comparison of the spectrum of the sun and that of an arc lamp shows that the differences are very slight. The spectrum of the carbon arc extends farther towards the red end, making water-cooling necessary in local treatment.

Open Arc Lamps

1. *Carbon Arc Lamps.*—The first artificial source of ultra-violet light was the carbon arc lamp introduced by Professor Finsen for the treatment of lupus so long ago as 1893—the world-renowned "Finsen Light." It consists of an automatically regulated 50-ampère arc lamp burning at 50 volts, having the carbons arranged in the vertical position, one above the other, the larger positive carbon being uppermost. Four metal tubes shaped like telescopes are suspended obliquely to collect and concentrate the rays.

These collecting tubes, which are a yard long, are each fitted with one plain quartz window and four convex quartz lenses. Some of the spaces between the lenses are filled with distilled water, while tap water runs through the metal casing which encloses the collecting tube.

Various types of compression apparatus are used for different parts of the body; they generally consist of a metal ring, 4·5 cm. in diameter, holding a quartz lens and a plain quartz window with a space between of 5 mm. Water circulates through this space, and has the effect of absorbing any remaining heat rays.

This compression apparatus is held by a nurse by its four handles and firmly pressed on to the part

under treatment, thus driving the blood from the tissues and allowing of greater penetration by the ultra-violet rays.

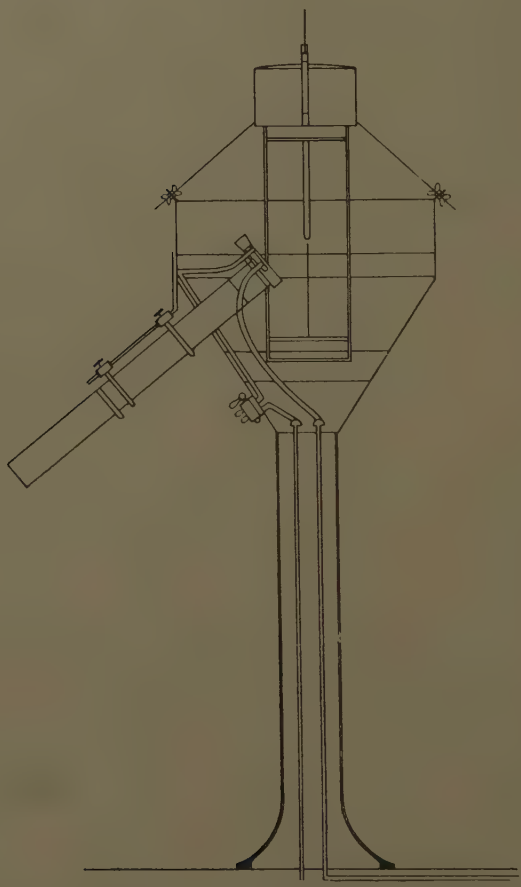


FIG. 20.—Diagram of the "Finsen" Lamp. (Reyn.)

Four patients are treated simultaneously with each "Finsen" lamp, and at the Light Institute at Copenhagen seven such lamps are in continuous use.

For the treatment of patients singly the "Finsen-Reyn" lamp was designed. It is an automatic scissor arc, taking 20 ampères at 50 volts. As in the "Finsen"

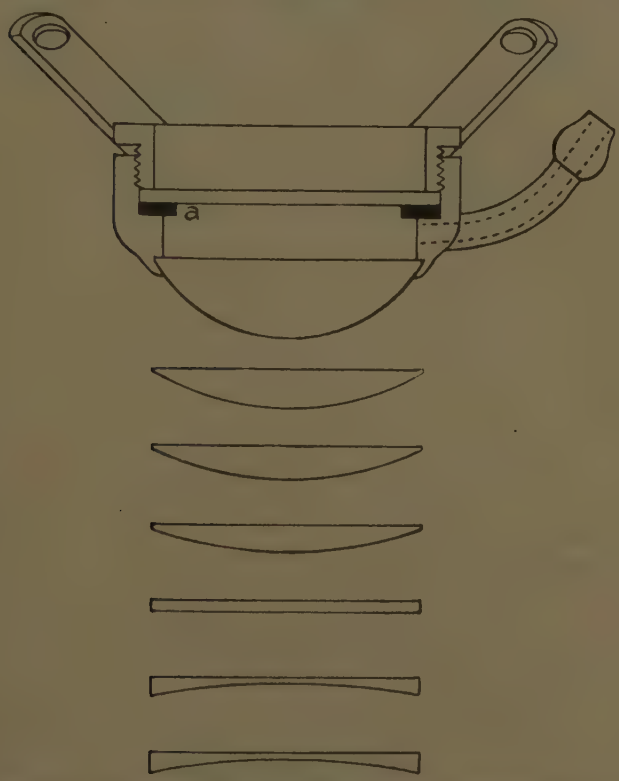


FIG. 21.—Diagram of Different Compression Lenses used with the "Finsen" and "Finsen-Reyn" Lamps. (Reyn.)

lamp there is a cylindrical metal collecting tube fitted with a quartz window and four quartz lenses. The heat rays are eliminated by filling the tube with distilled water and also by surrounding it with circulating tap water.

Quartz compressors are used in the same way as with the "Finsen" lamp. Special prisms of quartz

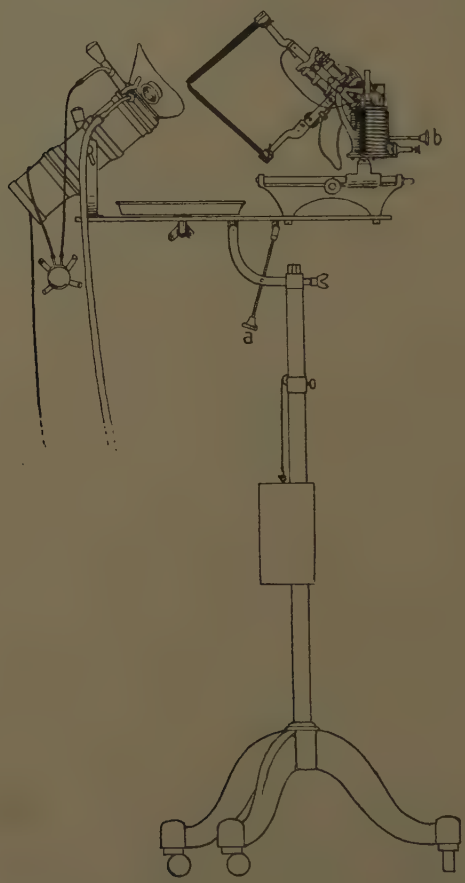


FIG. 22.—The "Finsen-Reyn" Lamp. (Reyn.)

have been made for use in the nose and ear, where it would be impossible to use the ordinary type of compressor.

Professor Reyn has also devised powerful carbon

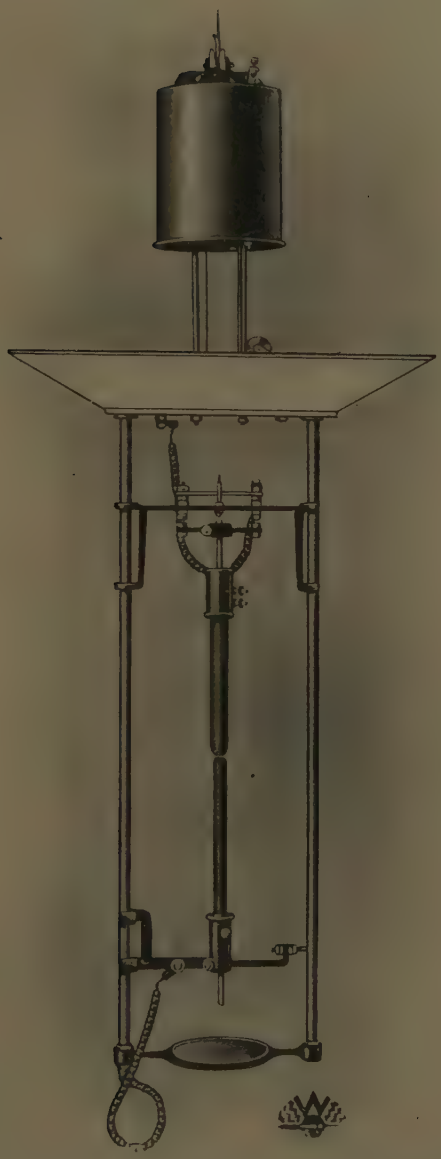


FIG. 23.—Carbon Arc Lamp, after Reyn (75 ampères). Capable of treating eight ambulant patients simultaneously. (Watson & Sons.)

short-flame arc lamps for general irradiation of the body.

(*a*) As a unit he uses two 75-ampère arcs burning in parallel at 55 volts; (*b*) and also three 20-ampère arcs which can be used in series, if the main supply current is used, and if the voltage is 220 or over.

The larger lamps are used for the treatment of six to eight ambulant patients together.

The 20-ampère lamps are used for the treatment of two recumbent patients. They are economical when only one or two patients have to be treated, as two couches can be placed close together with the lamps between; they are therefore very useful in general practice.

To secure the greatest emission of ultra-violet rays the thinnest possible carbons are used to carry the large current. The most satisfactory sizes have been found to be:

For 75-ampère lamp:

Positive,	31 × 300 mm.	plain-cored carbons
Negative	22 × 300 mm.	

For 20-ampère lamp:

Positive	12 × 300 mm.,	plain-cored carbon
Negative	8 × 300 mm.,	solid carbon

The distance between the 75-ampère lamps measured from arc to arc is 60 cm., and the distance from the floor to the positive carbon crater is 1 metre. The 20-ampère lamps are placed 55 cm. apart (carbon to carbon), and 1 m. 20 cm. from the floor, and about 35 cm. from the patient's couch.

We have mounted our 20-ampère arcs on a specially

FIG. 24.—Our method of mounting the three 20-ampère Short-Flame Carbon Arc Lamps used at the Finsen Institute.

made wooden trolley, which runs on four rubber-covered wheels. The switch and variable resistance

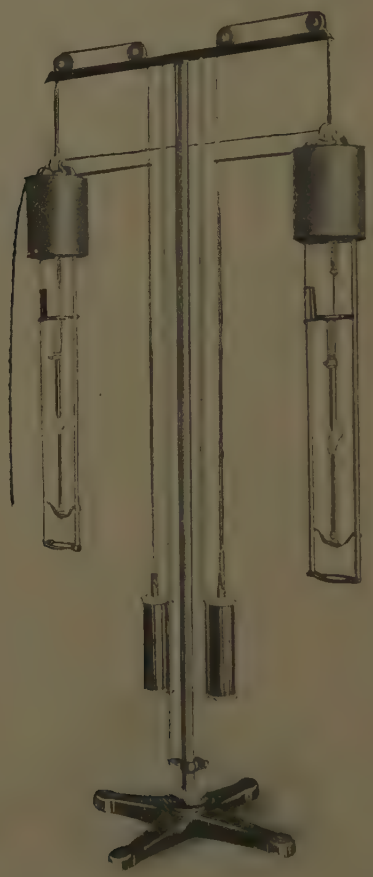


FIG. 25.—Two Carbon Arcs in Series, mounted on Floor-stand with Adjustable Counterweights; can be used on D.C. or A.C., taking 32 ampères (average), and Arc Voltages of 50 to 120 volts. (X-rays Ltd.)

are attached to one end of the trolley, and there are stout, horizontal handles to facilitate moving

the apparatus, which can be used in several rooms. Aluminium pans collect any falling pieces of carbon.

The "Belot" lamp consists of four arc lamps, whose height can be regulated, suspended from a trolley.

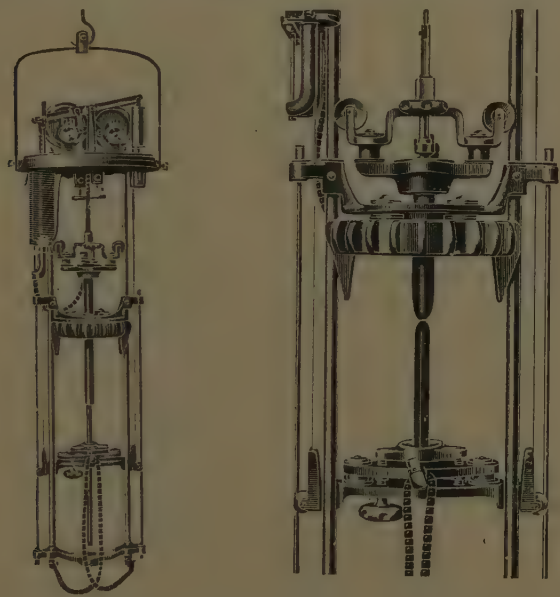


FIG. 26.—The Open "Flaming" Carbon Arc Lamp for Alternatimg Current or Direct Current. Automatic Feed (30 ampères). (Cox-Cavendish Electrical Co. Ltd.)

Each pair of lamps is arranged in series on 110 volts, and each pair separately consumes 15 ampères.

X-rays Ltd. make an apparatus consisting of two lamps in series mounted on a floor-stand; the lamps carry 30 ampères and are counterweighted; they may be used with either short or long flame arcs, the voltage being variable between 50-120. They may be operated on either A.C. or D.C.

The "Westminster" lamp is an automatically regulated long-flame arc with a standard wiring for 30 ampères. Two lamps can be used in series or parallel, depending on the voltage of the circuit.

FIG. 27.—Detail of "Sunic" Parallel Carbon Arc Lamp.

The "Sun Ray" lamp is another automatic feed lamp which can be used on 15-30 ampères at 120 volts.

There are several different types of "Jupiter" lamp. The stand model is an automatically regulated two-flame lamp, with two pairs of parallel electrodes. It

has an aluminium parabolic reflector and can be used on A.C. or D.C.—25 ampères, 110-220 volts.

The hanging type of lamp is for collective overhead treatment; it has two arcs at low voltages and three at 220, and it works at 60 ampères.

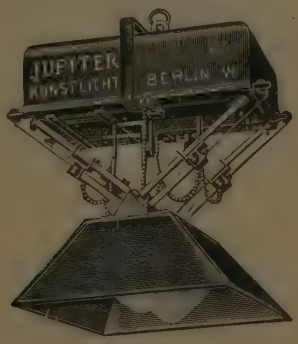


FIG. 28.—"Jupiter" Suspension Type of Carbon Arc Lamp with Two or Three Arcs, for Simultaneous Irradiation of a Number of Patients. D.C. or A.C., taking 60 ampères.

There is also a small portable table lamp designed by Professor Hartmann.

The "Ultra Sonne" lamps, Dr Landeker-Steinberg's design, are scissor carbon arcs; one is a hand-feed model and the others are automatically regulated. They work at 6 ampères, 110-220 volts; they are used a great deal for irradiation of the body cavities.

The "Arnold" lamp is a hand-feed carbon arc lamp, which has four flames on high voltages. The arcs burn in series, on either A.C. or D.C., at 15 to 25 ampères; different carbons can be used. In the "radial" type there are four arcs, which are automatically controlled and grouped round a

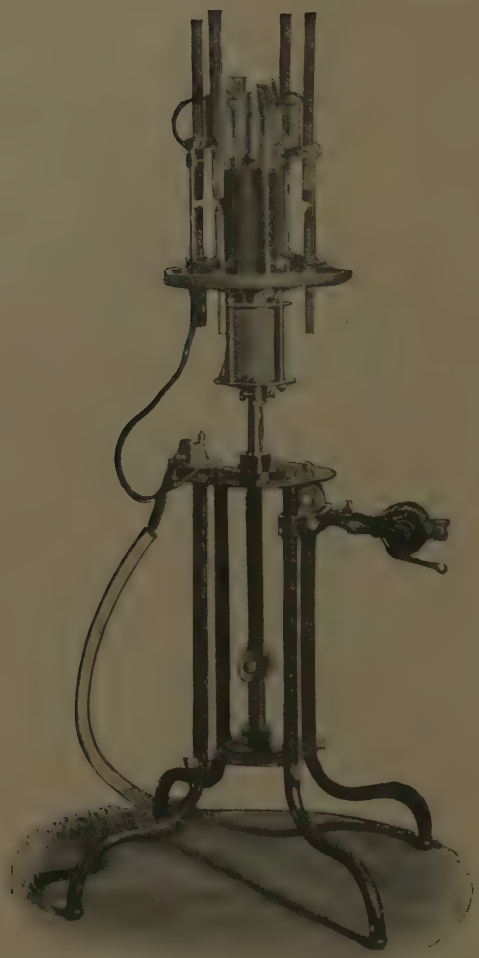


FIG. 29.—The "Arnold" Quadruple Carbon Arc Lamp with Automatic Regulation: Radial Type, for Collective Treatment.

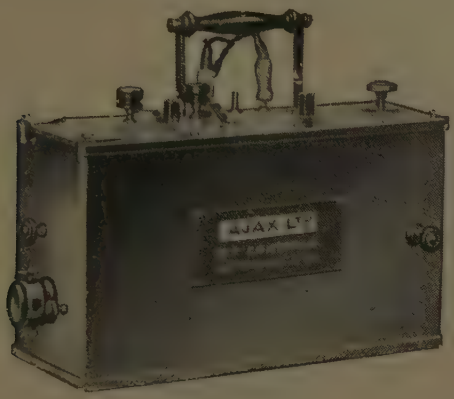


FIG. 30. — "Ajax" Portable Carbon Arc Lamp, with Automatic Regulation, which can be used on an ordinary House Electric Lighting Circuit.

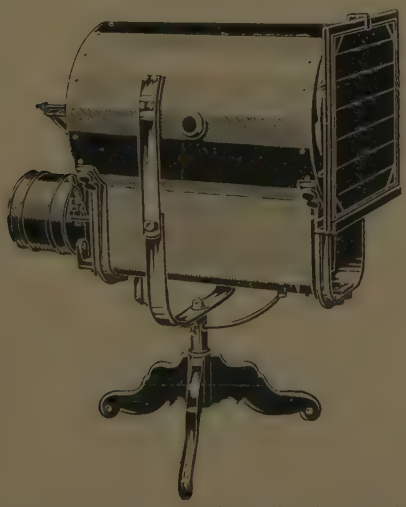


FIG. 31. — The "Radiosol" Automatically Controlled Carbon Arc Lamp with Horizontal Electrodes. D.C. 15 ampères. (Sanitas, Berlin.)

central nickelled reflector; it is useful for hospital work.

There are three different modes of "Saidman" lamps:

(*a*) A portable type, which weighs only 14 lb.; it

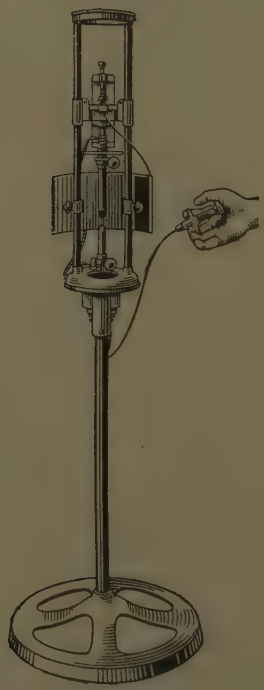


FIG. 32.—"Sunstar" Portable Hand-regulated Carbon Arc Lamp, taking 12 ampères.

works at 4-8 ampères; the carbons are inclined almost at a right angle and there is a magnetic blow-out.

(*b*) The cabinet type, which is entirely enclosed in a metallic case; this allows the use of quartz lenses for local treatment.

(*c*) The hospital type has three automatically regulated vertical arcs. The lamp uses 10-15 ampères at 220 volts.

The "Radiosol" lamp is a carbon arc with auto-

FIG. 33.—"Quain" Enclosed Carbon Arc Lamp with Automatic Regulation.

matic control, working at 15 ampères. For direct current it has horizontal electrodes, and for alternating current the carbons are inclined at a right angle.

The "Arnone" lamp is a small scissors arc hand controlled, working at about 5 ampères and used on either A.C. or D.C.

There are both table and tripod models.

The "Sunstar" arc lamp is a portable carbon arc,

FIG. 34.—The Stand Model of the "Heliol" Enclosed Carbon Arc.

burning most satisfactorily with a current of 12 ampères; it has a Bowden wire control and can be used with either current.

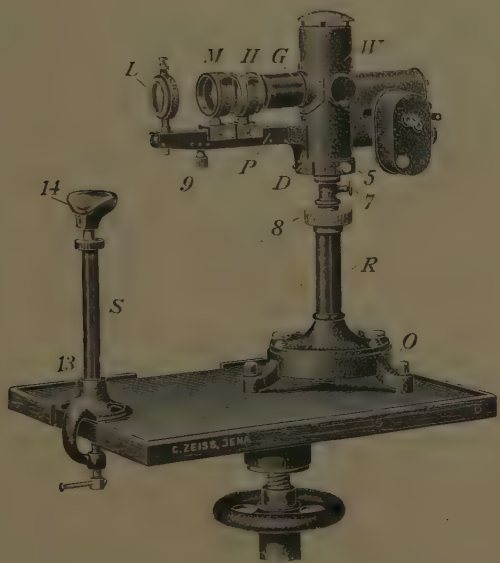


FIG. 35.—The "Birch-Hirschfield" Radiation Lamp for the Treatment of Inflammatory Affections of the Anterior Segment of the Eye. It requires direct current and takes 3 to 4 ampères.

H, Quartz Cooling Cell filled with a ferrous solution; M, "Uviol" Filter; L, Quartz Converging Lens, which is necessary for the treatment of small corneal ulcers; S, Chin-Rest.

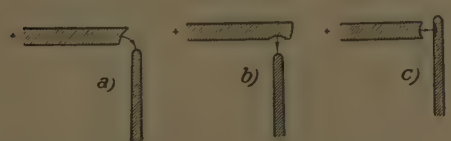


FIG. 36.—Carbons for the "Birch-Hirschfield" Radiation Lamp.

(*a*) Correct Position; (*b*) and (*c*) Incorrect Positions.

Enclosed Arcs.—The "Quain Quartz Arc" lamp has its arc enclosed in a "Vitreosil" quartz tube.

The "Heliol" lamp has the arc enclosed in a "Heliol" glass tube.

The violet-blue colour seen when this lamp is burning is due to the cyanogen and carbon monoxide which

FIG. 37.—"Schanz's" Special Carbon Arc Lamp for the Treatment of Diseases of the Eye. (Kohl, Leipzig.)

are formed. It is possible to obtain an arc length of 50 mm. with this lamp.

Special Types of Arc Lamp.—The Zeiss "Redfree" lamp is a small encased lightproof carbon arc lamp taking 5-10 ampères. One of the models has clockwork regulation of the carbons. The lamp is used for ultra-violet treatment of eye diseases.

"Schanz's Eye Radiation" lamp consists of a special 12-ampère arc lamp, which is inserted into

a lightproof casing having four windows made of blue Uviol glass, which allows only rays of 4000 Å to 2650 Å to pass. Four patients can be treated simultaneously.

FIG. 38.—Portable Tungsten Arc for Local Treatment. (Arnold & Sons.)

2. *Tungsten Arc Lamps.*—The tungsten arc was first used as a source of ultra-violet rays as the "Simpson Light," which was proved by Professor Sydney Russ to be wolfram, a tungstate of iron and magnesium.

The "Simpson" arc burns very irregularly; it uses 5-7 ampères at about 70 volts, and is provided with reflectors.

Dr W. J. Turrell, of Oxford, about the same time

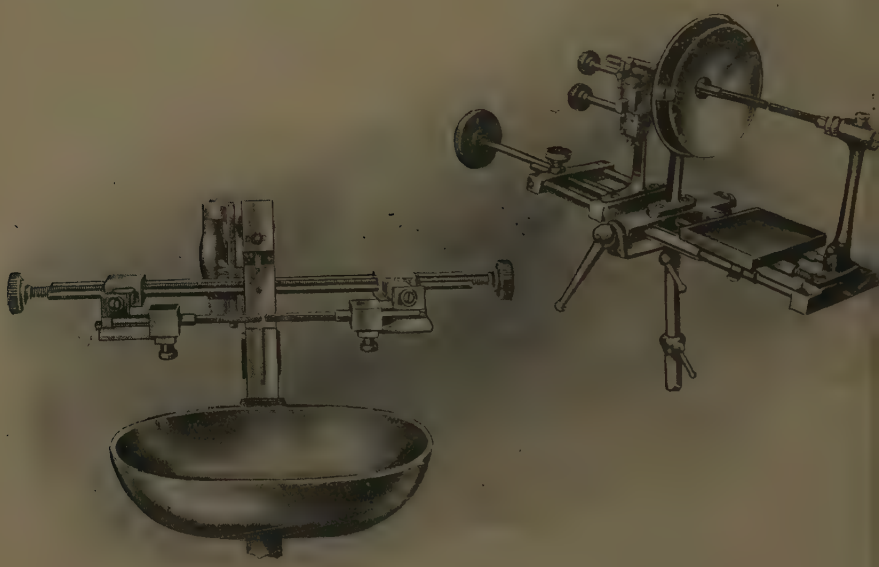


FIG. 39.

Tungsten Arc Lamp; for use on Direct Current.

"Premier" Tungsten Arc Lamp; for local irradiation. Used with D.C. Consumption 5 ampères.

made use of pure compressed tungsten electrodes, and found that they burned very evenly, with but little spluttering, and gave a spectrum richer in ultra-violet radiations than the wolfram electrodes.

Various modifications have been used—*e.g.* carbon rods impregnated with sodium tungstate, uranium

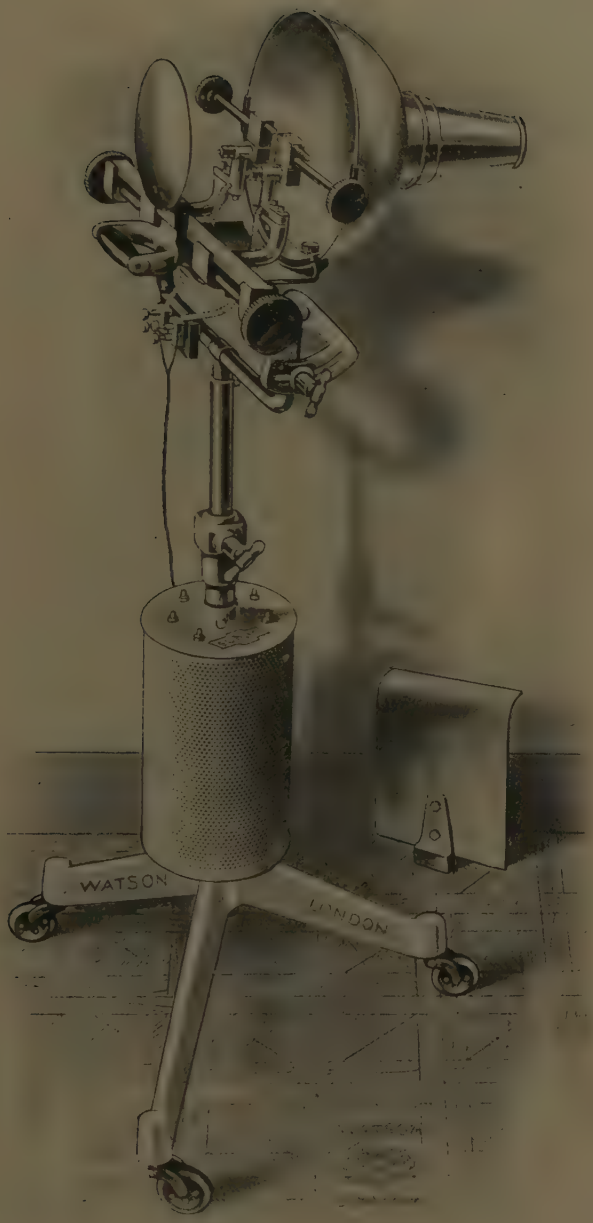


FIG. 40.—A new type of Tungsten Arc Lamp for Local or General Treatment.

nitrate, ammonium molybdate, and titanous chloride, and also carbons cored with uranium oxide, wolfram, pure molybdenum, and tungsten in the form of powder.

FIG. 41.—Tungsten Arc Lamp. Three Lamps and Reflectors fitted on Stand; also 1000 c.p. Gas-filled Lamp. Switches and Resistances arranged on wall. (T. Clark & Son.)

Schunk found that the richest and most intense source of ultra-violet radiations was tungsten metallic electrodes with lines extending to 2000 A°. He found that the molybdenum spectrum was very similar to that of

tungsten, but with much weaker lines below 2300 Å. Carbons cored with tungsten metallic powder gave almost the same result as when metallic tungsten alone was used. These carbons are much less costly than pure tungsten electrodes, but the ampèrage must be slightly increased.

There are also electrodes made of tungsten and chrome steel; these give off brownish fumes of iron oxide and a greatly thickened crater forms, which has to be broken off before the electrodes are again used.

A common type of tungsten lamp is one in which the electrodes are in the horizontal position; the arc is hand-fed, and usually consumes about 5 ampères at 60 to 100 volts. It has a copper reflector which absorbs fewer rays than an ordinary mirror. When local application is required the rays may be concentrated by means of a quartz lens, 2 in. diameter, with a focal length of 4 in. The surrounding parts must be protected, and the exposed area placed at a distance of 12 in. from the lamp.

T. Clark makes a tungsten lamp which has three arcs mounted on a movable iron base; the arcs are fitted with detachable aluminium hoods and each arc consumes 5 ampères. He has also made a tungsten arc bath in the style of a radiant-heat cabinet.

The "Arnold" tungsten arc hand lamp is a 5-ampère lamp, with a quartz lens for local treatment.

The "Densolarc" is a 6-ampère, self-regulating, dental lamp fitted with a quartz concentrator.

Attempts have been made to manufacture a closed tungsten arc—the "Pointolite," made by the Ediswan Company. The arc is formed between a special

filament and a small ball of tungsten. It is enclosed in a quartz bulb. It forms a weak source of ultra-

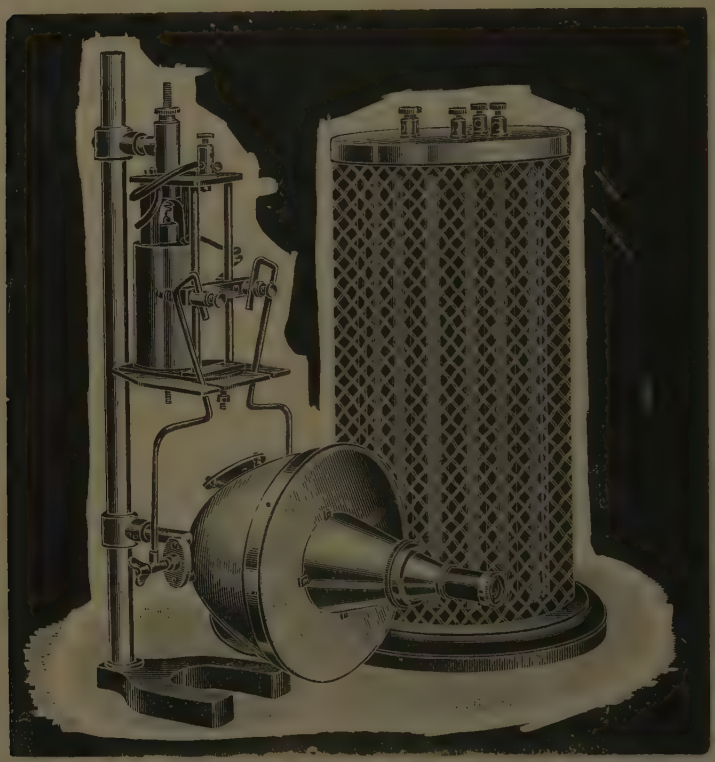


FIG. 42.—A Dental Model Tungsten Arc Lamp with Automatic Regulation, designed by Norman Black. Direct Current, 6 ampères. (Medical Supply Association.)

violet radiation as it is deficient in the rays of greatest therapeutic effect.

Luckiesh says an arc between tungsten electrodes operated in an atmosphere of hydrogen and nitrogen is a source of intense ultra-violet radiation.

The Iron Arc Lamp.—Professor Bang has designed

a water-cooled iron arc lamp. The electrodes have hollow centres and are cooled by running water.

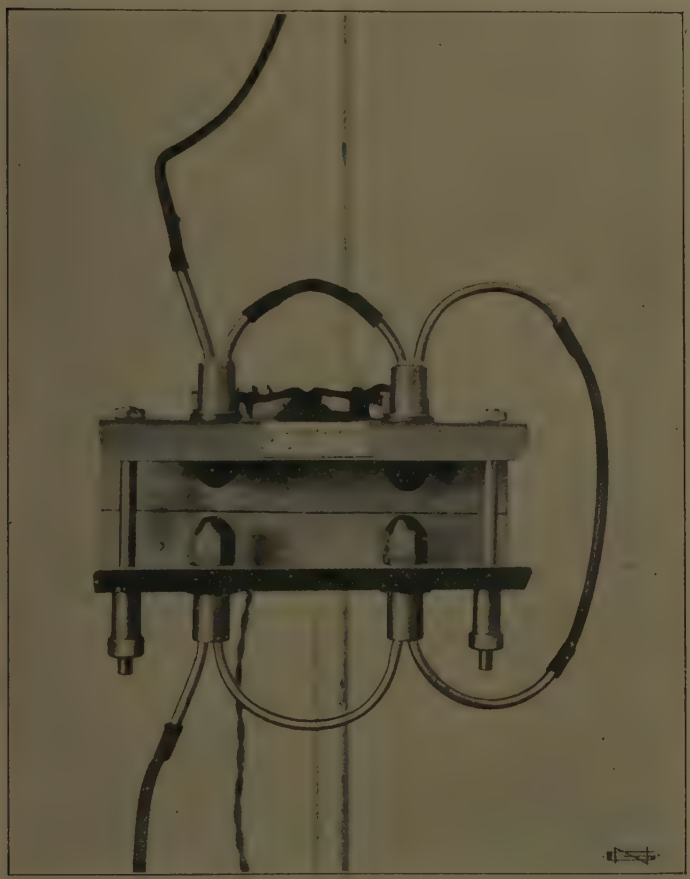


FIG. 43.—Details of Professor Bang's Iron Arc Lamp. (Levring & Larsen, Copenhagen.)

We saw one of these working in Copenhagen, and one also in the Light Department at Alton. The

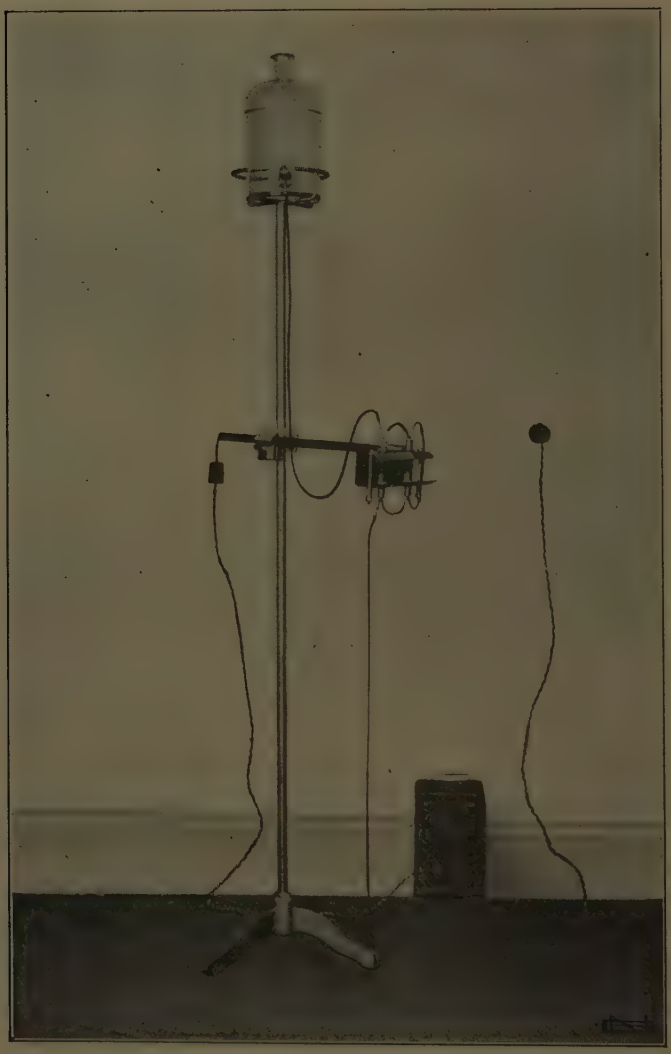


FIG. 44.—Professor Bang's Water-cooled Iron Arc Lamp. (Levring & Larsen, Copenhagen.)

spectrum of the iron arc is less continuous than that of tungsten, and extends only to 2250 Å; but the cost of iron electrodes is insignificant compared with the cost of tungsten. This makes the lamp very cheap to use. Sir Henry Gauvain has found it very useful in the treatment of local superficial lesions.

Arcs struck between copper electrodes and silicon have been used successfully, the latter emitting intense ultra-violet radiation, with very little accompanying visible light.

Zinc, cadmium and aluminium have also been used satisfactorily.

CHAPTER V

QUARTZ MERCURY VAPOUR LAMPS

The Mercury Vapour Lamp in Industry—The Essentials of the Mercury Vapour Lamp—Classification of Mercury Vapour Lamps—Different Types of Air-cooled Vacuum Burners—The Functioning of the Mercury Vapour Burner—Care of the Burner—The Non-Vacuum Burner—Alternating-Current Burners—The Water-cooled Mercury Vapour Lamp—The "Kromayer" Lamp—The "Victor" Water-cooled Burner—The Spectrum of the Mercury Vapour Lamp—Methods of Supporting the Burner

THE first mercury vapour lamp was made by Arons, in 1892, but its use was confined to the laboratory. An American engineer, Peter Cooper Hewitt, constructed, in 1901, the first mercury vapour lamp to be used commercially; the arc was enclosed in a long glass tube.

Apart from medical purposes the mercury vapour lamp is used principally in photographing cinematograph films, in drawing offices, and in newspaper printing, as it gives a visual acuity fifty per cent. greater than white light.

Kuch and Heraeus, who in 1904 discovered a method of melting natural quartz, were the first to replace the glass of the Cooper Hewitt tube by quartz, which allowed higher temperatures and pressures to be used.

The mercury vapour lamp consists of several essential parts, the burner being the principal, but it

is also necessary to have a means of lighting the arc, also a support for the burner, and a reflector of some pattern is generally used. A rheostat is needed to control the current required for the proper functioning of the lamp under the varying conditions which occur at different times after the lamp's ignition.

The burner of the mercury vapour lamp consists primarily of a tube of clear quartz containing some mercury.

When an electric current is passed through the tube there is a temporary short circuit, heat is generated which causes some of the mercury to volatilize, and an intense illumination results.

The spectrum from the arc is very rich in ultra-violet radiations and extends far beyond the limits of the solar spectrum.

Kromayer, in 1905, designed the lamp known by his name. It is an interesting fact that the rather complicated "Kromayer" lamp was the first to be used, but at the commencement ultra-violet treatment was restricted to local applications; and it was only when Bernhard and Rollier's work became better known that the air-cooled lamp was invented.

Dr Schott's "Uviol" lamp consists of a tube of Uviol glass about 60 cm. long, containing some mercury. Carbon terminals inside the tube are connected with platinum wires, which are fused into the extremities of the glass.

Rays down to 2530 Å are allowed to pass, but for medical purposes the lamp has been superseded by the quartz lamp.

Quartz is a mineral which is commonly found on

the earth's surface, but rarely in its pure, colourless, crystalline form; usually it is tinted yellow, violet, blue or brown. Silver sand consists of quartz. Quartz crystals are rhombohedral, and chemically quartz is silicon dioxide (SiO_2).

Mercury vapour lamps can be divided into:

(1) Air-cooled.

(2) Water-cooled.

In the case of air-cooled lamps cooling can be effected by (*a*) radiation from metal coolers; (*b*) a mechanically produced air blast.

Air-cooled lamps include those in which the arc is struck:

(1) In vacuum.

(2) In some inert gas, such as argon.

(3) At atmospheric pressure.

Air-cooled lamps can also be subdivided into:

(1) Those which have to be tilted to produce the arc. (The tilting may be (*a*) performed by hand or (*b*) magnetic.)

(2) Those which start automatically:

(*a*) By means of an auxiliary heating system (1) outside burner; (2) inside cavity of burner.

(*b*) By an initial high-tension discharge.

The commonest types of vacuum mercury vapour lamps are:

(1) The "Uviarc" lamp, made by the Victor Company (Chicago) and by the Cooper Hewitt Company.

(2) The "Hewittic" lamp.

(3) The "Hanau-Hanovia" lamp.

(4) The "Quartz Transparent" lamp, Paris.
(5) The "Silectra" lamp, Leipzig.
(6) The "Vignard" lamp, made by Gallois et Cie, Lyons.
(7) The "W. Ulbrich" lamp, Jena.
(8) "Le Quartz Dimant," Paris.
(9) The "Lasem" lamp, Paris.

FIG. 45.—Air-cooled Type "Uviarc" Quartz Tube. (Victor X-ray Corporation, Chicago.)

(1) The "Uviarc" lamp consists of a cylindrical pipe-shaped quartz tube, the cathodal chamber corresponding to the bowl of the pipe, and containing mercury. The tungsten electrode wires are fused to glass, which is in turn connected to the quartz of the tube through intermediate steps of glasses of decreasing coefficients of expansion; this has made it possible to use a solid tungsten anode, and, as a result, to work the burner at high temperatures, without the use of metal-cooling fins. The lamp is lit by tilting the cathodal end so that metallic contact is made by the mercury from the cathode momentarily touching the tungsten anode. During operation the mercury

is entirely confined to the cathodal chamber, partly by mercury vapour pressure and also because the cathode lies at a lower level than the anode.

(2) The "Hewittic" lamp, which is made in England, is so similar in construction to the "Hanau" and "Hanovia" lamps that one description of the

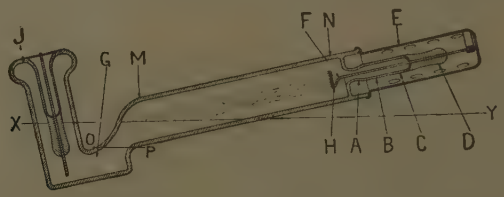


FIG. 46.—Diagram of "Uviarc" Air-cooled Quartz Mercury Vapour Burner.

A, Quartz Stem of Seal Structure; B, Connexion of Quartz Stem and Seal Grading; C, Connexion of Seal Grading and Seal Coating; D, Tip of Seal Coating; E, Anode Seal Guard; F, Tungsten Electrode; G, Cathode Mercury Pool; H, Anode Target; J, Cathode Chamber; M-N, Luminous Portion; X-Y, Level of Mercury when cold; O-P, Level of Mercury during operation.

three will suffice. The new "Hewittic" burner has, however, no cooling vanes.

(3) The "Hanau" lamp is manufactured in the small town of Hanau, near Frankfort, Germany. The quartz of this and of the "Hanovia" lamp is considered particularly transparent, as great skill has been acquired in working this material since W. C. Heraeus, of Hanau, first succeeded in fusing quartz crystal. The "British Hanovia" lamps are made in England, at Slough.

A Common Description of the Burners of Lamps (2) *and* (3).—The direct-current burner consists of a transparent quartz tube, "the arc tube," $1\frac{1}{2}$ to 2 milli-

metres thick, varying in length from three to five inches, according to the voltage, and having at each end transverse polar vessels also made of quartz; these contain a fixed bundle of quartz rods to lessen

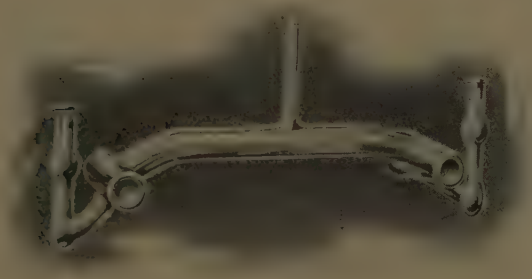


FIG. 47.—The Hewittic "Ulviarc" Quartz Burner before assembly.

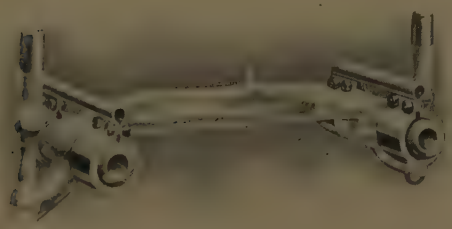
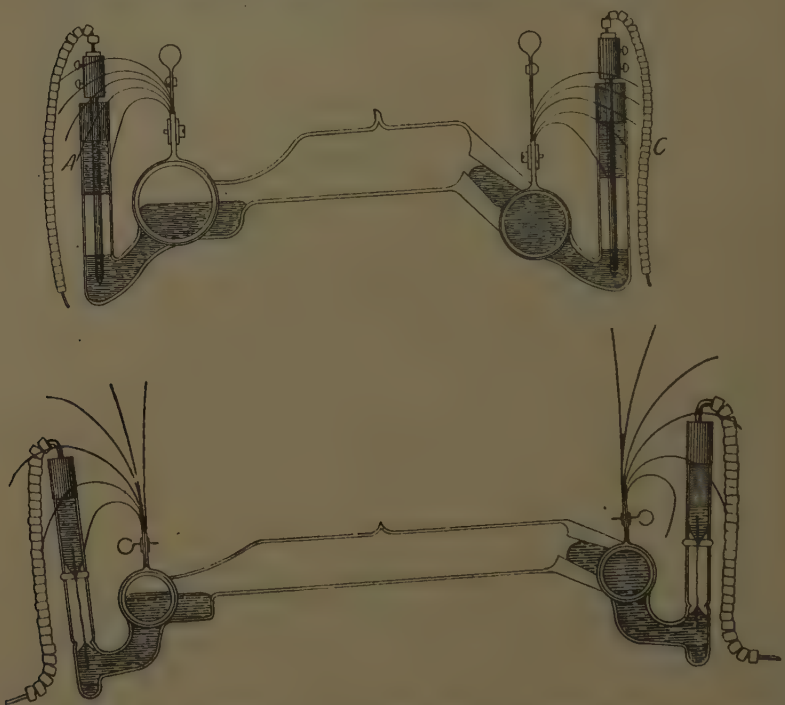


FIG. 48.—The Hewittic "Ulviarc" Quartz Mercury Burner completed. Note the absence of Aluminium Cooling Vanes.

the amount of mercury required. When in position the burner is slightly out of the horizontal plane, the anode, generally on the left-hand side, when the burner is viewed from the front, being a little lower than the cathode.

At the cathode, where the arc tube joins the polar

vessel, the quartz is very much thickened, the internal narrowed portion being cone-shaped, this portion of



FIGS. 49 and 50.—Diagrams of two Quartz Mercury Vapour Burners (Vacuum Type) manufactured by the Quartz Transparent Co. In each case the anode is on the left and the cone and negative terminal on the right. To strike the arc the anodal end must be first tilted, so that the mercury in the anodal chamber comes momentarily into contact with the mercury in the cone, and then lowered. The Upper Diagram illustrates a Burner for 110 volts, and the Lower—for 220 volts—shows the much longer Arc Tube. The Aluminium Cooling Vanes attached to the polar vessels can be seen.

the burner being known as "the cone." The cone plays an important part in regulating the even working of the burner.

The cathode is cooler than the anode, so liquid

mercury tends to be deposited at the cathode. The more mercury deposited at the cathode the higher its level in the cone, and therefore the smaller the surface of mercury in contact with the luminous arc—therefore the greater amount of heat developed, and consequently the more mercury volatilized. In this

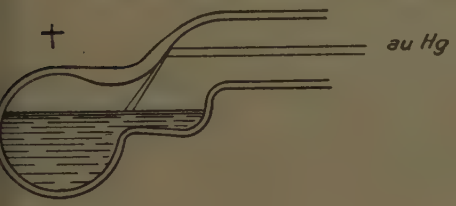


FIG. 51.—Showing the Thickened Projection on the upper part of the Burner at the junction of the Arc Tube and the Anodal Reservoir. This diverts the Luminous Arc Stream on to the surface of the Liquid Mercury. (Saidman.)

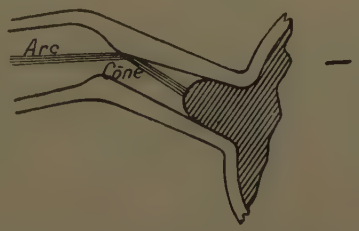


FIG. 52.—Illustrating the Cone which is situated at the junction of the Arc Tube and the Cathodal Polar Vessel. The Quartz Walls of the Burner are considerably thickened at this point. The Cone plays an important part in regulating the surface area of mercury in contact with the luminous arc, and thus maintains equilibrium in the burner. (Saidman.)

way the amount of mercury vapour in the burner is regulated and kept fairly constant. When the lamp has reached its normal output, and the electrical energy input equals the radiation from the burner, the luminous column occupies only the centre of the arc tube. A special projection at the cathode end deflects the arc stream on to the relatively small cathode surface almost at right angles.

On the upper surface of the anodal end of the arc tube the quartz is thickened to form a slight protuberance into the lumen of the burner.

On the lower surface below this the anodal mercury reservoir is continued into the arc tube. The thickened projection of quartz on the upper internal surface of the arc tube deflects the arc stream almost at right angles on to the surface of the mercury.

The terminal vessels are surrounded by metallic coolers and contain the mercury poles. The coolers

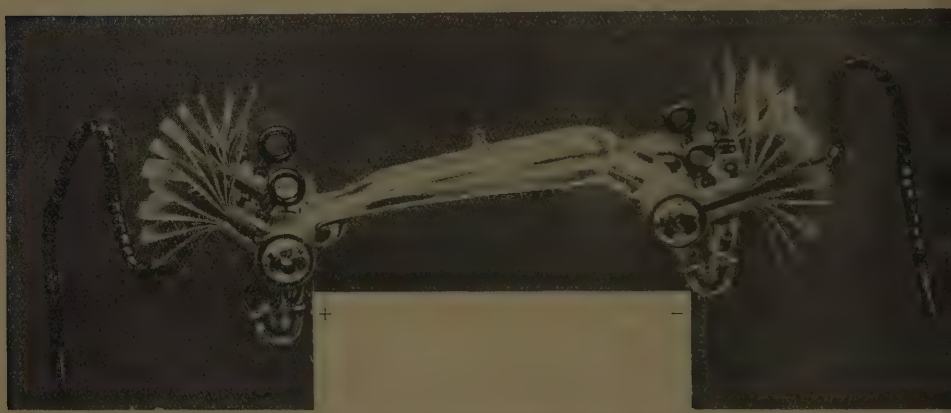


FIG. 53.—Direct-Current Type of Air-cooled Quartz Mercury Vapour Burner, for use with 220 to 2[illegible] volts. The Anode is seen on the left and the Cone and Cathode on the right. (Ajax Ltd.)

control the mercury distribution in the lamp by heat regulation. Conductors are ground or sealed into the quartz, enabling the external current to enter the polar vessels between the coolers. Inside the vacuum of the tube the mercury vapour carries the current from one inside terminal to the other. Two sockets, which enable the burner to be held in place, are fastened to the coolers. The tube was originally made of quartz because of its very high melting-point, of about 1700° C., which made it possible to use lamps at a much higher temperature than was possible when

they were made of glass. Another advantage is that the coefficient of expansion and contraction of quartz is only ·00000059 inches per degree centigrade. Again, about a thousand times more ultra-violet radiation is allowed to pass through quartz than through glass.

In the process of manufacture all gases are removed by a temporary opening in the middle of the upper surface of the arc tube and a vacuum formed. When the lamp is in use a direct-current arc forms between the positive electrode of iron, carbon or tungsten and the mercury cathode; the tube becomes filled with electrons, molecules and ions of mercury, and there is a constant movement of electrons from the cathode to the anode and vice versa.

This type of burner must be operated by direct current, and mercury must form the cathode, because a substance must be maintained at a sufficiently high temperature to emit electrons to act as a cathode, and, as Fleming explains, mercury has a relatively low boiling-point, a small latent heat of vaporization, a low specific heat and a low ionization potential.

Striking the arc generates intense heat on the comparatively small surface of the mercury cathode. Electrons are freely formed, and a high cathodal temperature at one spot is maintained by ionic bombardment, the ions being derived from the mercury vapour between the electrodes.

On the other hand, it is difficult to maintain local heating of iron or tungsten at a high temperature; and if alternating current were used the iron and mercury would alternately become negative; and, as already mentioned, iron is not suitable as the cathode.

The mercury arc is therefore a unidirectional conductor, the maintenance of the small cathodal hot area being essential.

There is a variation in the arc temperature of the

FIG. 54.—Diagram of the Correct Burning Position of the Vacuum Type Quartz Mercury Vapour Burner.

FIG. 55.—Diagram of the Incorrect Burning Position of the Vacuum Type Quartz Mercury Vapour Burner, which will cause Burner Failure.

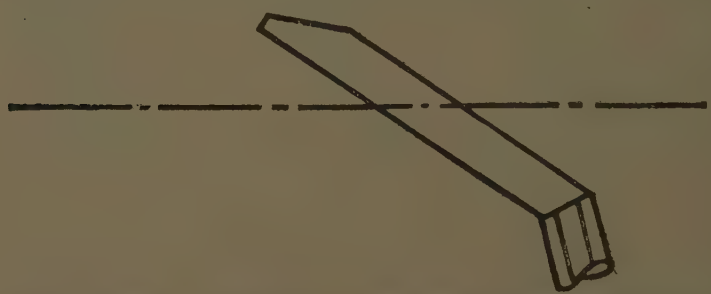


FIG. 56.—Diagram of the Position of the Vacuum Type Quartz Mercury Vapour Burner when tilted to start. The Anode has been raised.

tube from the centre to the surface of 1400° to 450° C., and the vapour pressure is usually a little over an atmosphere.

To ensure steadiness in the arc stream the lamp is operated out of the horizontal plane, the anode generally being at a lower level than the cathode. The arc may be struck if the mercury cathode is brought into

contact with the anode by tilting the lamp while the current is turned on, thus causing the mercury to flow across the burner, and then lowering the anode to its original plane, causing the breaking of the stream. Compared with a filament incandescent lamp the mercury vapour lamp is relatively cold, as the luminescent vapour registers a temperature of 200° to 500° C., while the filament lamp usually has a temperature of 2800° C. Quartz will stand very high temperatures, but it has to be handled carefully as it is fragile. It must also be kept scrupulously clean and free from grease and dust; the tube must not be fingered, as imprints become etched into the quartz and cannot be removed. Cleaning is best effected with a piece of silk soaked in rectified spirit.

The characteristic odour which is present near an active mercury vapour lamp is due to the formation in the air of hydrogen peroxide, ozone and nitrous acid. Ozone is produced in considerable quantities, especially shortly after the lamp has been lit. The smell is not unpleasant, and does not seem to have any bad effects.

Some time ago we had experience of the variation in intensity of lamps. A "Hewittic" lamp was broken by the resistance being inadvertently cut out, and the whole pressure of 240 volts being put through the lamp cracked the quartz. On the arrival of a new lamp slight overdoses occurred when the same exposures were given. Later in the life of the lamp some air leaks into the vacuum, causing a change in the composition of the gas in the tube, and a brownish grey stain occurs on the inside of the quartz, again

decreasing the emission of rays. The evacuated type of burner generally needs replacement after it has been in use for 800 hours (longer exposures are generally required after 400 hours). The burner should then be returned to the makers, who usually treat the interior with nitric acid, re-evacuate and seal. Sometimes, however, it is necessary to replace the arc tube of the burner by a new tube. Taylor and Griffith found that some mercury vapour lamps, when they were new, gave off nearly eight times as much ultra-violet radiation as when they had been used for 800 hours.

It has also been found that when deterioration occurs with age in a quartz mercury vapour lamp it is particularly the rays below 2540 Å which are cut off.

All the foregoing lamps must be tilted to strike the arc. Care must be exercised not to reverse the polarity of the terminals, both at the switchboard and lamp ends, or the lamp will be destroyed. It is customary to make the wall plugs with pins of different sizes to avoid mistakes.

The direct-current "Quartz Transparent," "Silectra" and "Lasem" burners are very similar to the "Hanau-Hanovia."

The "Ulbrich" burner has a special mercury seal, which obviates the need for aluminium cooling fins. The hood also contains the resistance specially mounted above the middle of the quartz burner, so as to provide the maximum emission of infra-red radiation. The lamp is lit by tilting the whole reflector hood. The cathode is on the left-hand side.

The "Quartz Dimant" is a compact, portable

apparatus, having a special quartz mercury burner which is automatically lighted by means of the high-frequency current. The apparatus can be used for either ultra-violet or high-frequency work, and is very convenient for local applications.

FIG. 57.—The "Henri George" Quartz Mercury Vapour Burner for 240 volts D.C. This burner, which contains Argon, lights automatically without tilting.

The "Henri George" burner has at each end two terminal reservoirs filled with mercury. The anodal, which lies on the left, has two auxiliary chambers attached to it: one, the heating chamber, contains a laminated nickel chrome wire; the other is the balancing chamber, which acts as a receptacle for

the mercury which is displaced when the lamp is in use. It has at its base a constriction with a passage

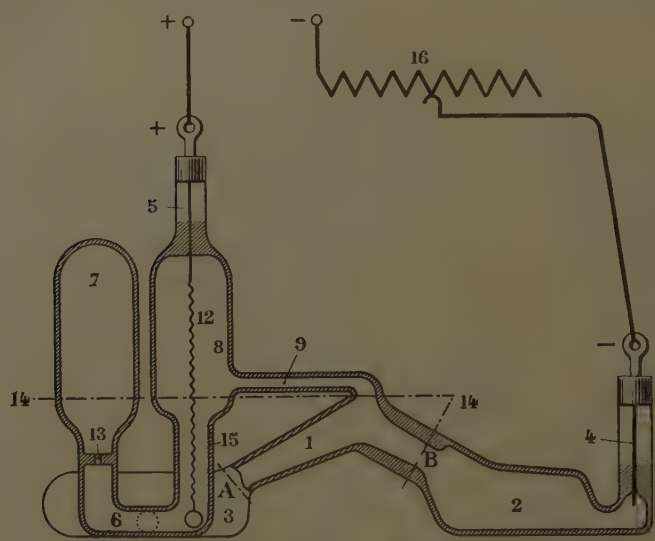


FIG. 58.—Diagram of the "Henri George" Quartz Mercury Vapour Burner.

1, Arc Tube; 2, Cathodal Mercury Reservoir; 3, Anodal Mercury Reservoir; 4, Negative Terminal; 5, Positive Terminal; 6, Tube connecting Chambers 7 and 8; 7, Hollow Chamber with constricted neck, 13, at its base, pierced by a small opening only 1 mm. across; 8, Hollow Oval Chamber containing laminated Nickel Chrome Wire, 12; 9, Tube connecting 8 with the Upper Part of the Arc Tube, 1; 14—14, Level of Mercury when Lamp is not lit; 15, Tube connecting Anodal Reservoir, 3, and Chamber, 8; 16. Rheostat.

A to B, Arc assumes this position in 5 to 10 seconds after the switch has been closed.

only a millimetre wide for the purpose of steadying the mercury.

When the current is switched on, the laminated nickel chrome wire (12) quickly becomes red-hot, and causes the inert gas, argon, which at first fills the chamber 8,

and in fact the whole burner above the level 14 –14, to rapidly expand and press the mercury downwards in the tube 15, and also at the junction of the tubes 1 and 9. Most of the displaced mercury passes through the narrow opening at 13 and collects in the balancing chamber (7), where it remains the whole time the lamp is burning. The expanding gas in

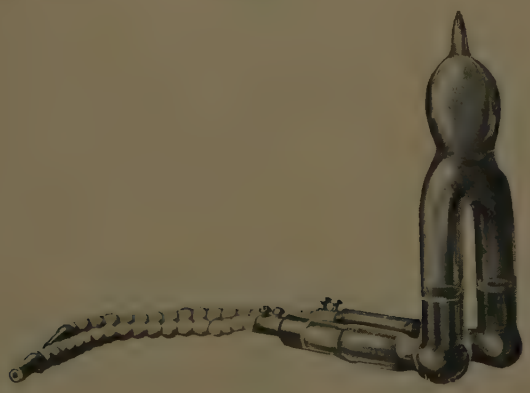


FIG. 59.—Quartz Mercury Vapour High-Frequency Burner. (Gallois et Cie.)

this manner breaks the continuity of the mercury column in the uppermost part of the arc tube and the arc is then struck, the arc stream rapidly lengthening until it occupies the position A—B. The whole process takes only a few seconds.

Gallois et Cie also make a burner which works with the high-frequency current; it is shaped like an inverted ∩ and is very compact.

(*b*) *Lamp having the Arc struck at Atmospheric Pressure.*—The burner of this lamp, the "K.B.B.," is manufactured at Wallsend-on-Tyne by the Thermal

Syndicate Co. for Messrs Kelvin, Bottomley & Baird. It has a quartz body and is self-starting. The "K.B.B." quartz mercury vapour lamp differs from those made hitherto inasmuch as it is open to the atmosphere instead of being sealed in a vacuum. The result is a

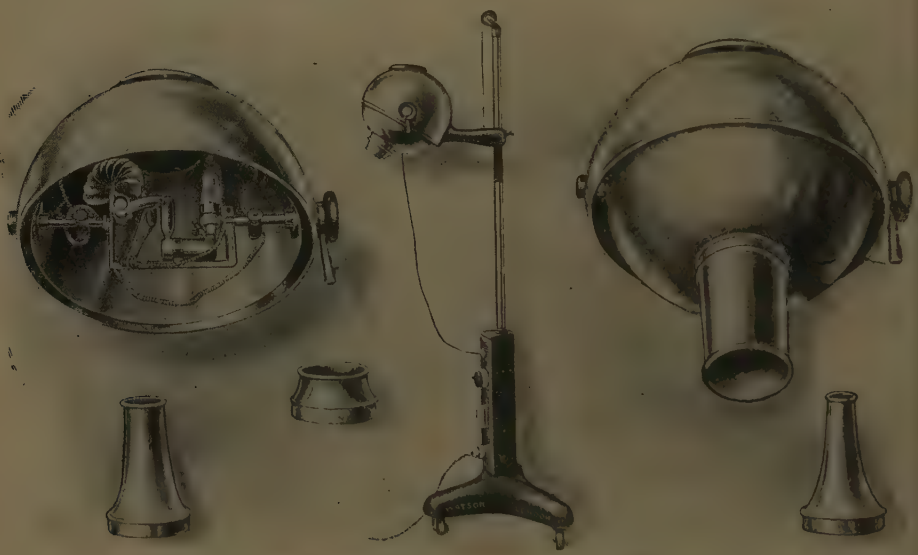


FIG. 60.—"K.B.B." Atmospheric Mercury Vapour Lamp.

lamp having some advantages over the vacuum type. The atmospheric type of lamp has greater mechanical strength, which is due to the fact that the lamp is completely sealed with mercury when it is not in operation and it is not therefore possible for any mercury hammer to take place in the lamp when it is transported from place to place, as is the case with the vacuum type lamps, which contain a quantity

of mercury free in the exhausted envelope of the lamp.

As there is no vacuum inside the lamp, no airtight seals are required between the quartz envelope and the leading-in conducting wires, and loss of vacuum due to leakage is entirely eliminated. Staining is avoided and the inside of the tube may be cleaned, when a mercury film has formed, by treating it with pure nitric acid, and then washing it out freely with distilled water and finally with absolute alcohol.

However, with continued use, all lamps, whether atmospheric or vacuum types, give off less ultra-violet radiation, as a chemical change occurs, and some of the quartz is converted into tridymite, a substance which is less transparent to the rays.

Tridymite and quartz are probably polymers of the molecule SiO_2; tridymite, being the less complex polymer, is more stable at high temperatures; it has a specific gravity of 2·3 compared with 2·65 for quartz.

Experimentally it has been found that, if quartz glass is devitrified at 1200° C., homogeneous tridymite is formed.

This type of lamp has the advantage that it has no moving parts which might get out of order; the only part which may require very occasional renewal is the small fireclay tube on which is wound some resistance wire, and which will be found towards one end of the lamp. These tubes can be had very cheaply, and it is quite an easy matter to fit a new one in the place of the old tube should anything happen to this at any time.

Two of these burners which were put on a life test

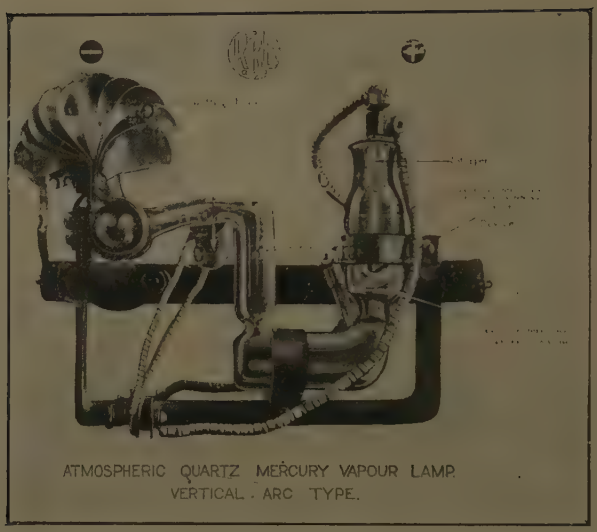


FIG. 61.—Atmospheric Quartz Mercury Vapour Lamp—Vertical Arc Type. (Kelvin, Bottomley & Baird.)

FIG. 62.—Method of holding "K.B.B." Burner.

in 1922 have been burning continuously night and day ever since, and they are still burning steadily —although, of course, the ultra-violet emission has fallen off considerably by now. Except for one short

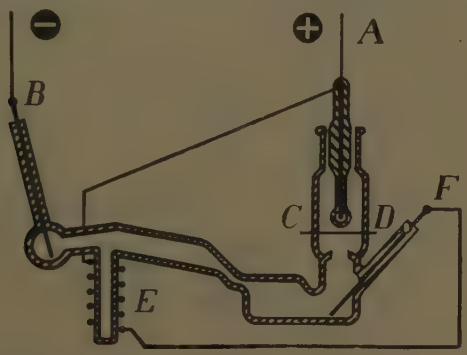


FIG. 63.—Diagram of the "K.B.B." Atmospheric Burner.

When the current is switched on, but before the lamp is lit, the positive electrode, A, is clear of the mercury, and the current thus flows from A through the heating coil, E, into the mercury at F, and thence to the negative pole, B. Mercury vapour generated in the branch, E, causes the mercury column in the main tube to break at the constriction at the junction of E. The arc is thus struck. Mercury vapour forces the mercury upwards from the level C—D till it reaches the electrode, A, thus cutting the heater, E, out of the circuit. When the current is switched off the mercury again assumes the level C—D.

period in the summer of 1924, when these lamps were taken down during cleaning operations, they have not been turned off.

The above diagram illustrates the lamp out of action. The whole tubing below and beyond the level C—D is filled with mercury, and into this at B projects

the negative electrode, which is a tungsten wire. In the condition represented in the diagram the positive electrode A stands clear of the mercury, and hence no current can pass from A to B through the mercury; but there is, as will be seen, an alternative path from A round a heating coil placed on the branch E and into the mercury at the branch F, whence the current proceeds through the mercury to the negative electrode at B. Mercury vapour generated in the branch E by the heating coil passes into the main tube, which is somewhat constricted where the branch E joins on. This vapour causes the mass of mercury to break in two at this constriction, thus striking the arc. The portion on the left is forced back by the mercury vapour and ultimately raises the level C—D up to the electrode at A.

The current now has a direct passage through the electrode A to the mercury, instead of having to pass through the heating coil and back through the branch F. The heating coil is thus short-circuited and remains out of action while the lamp is in operation. Should, however, the current be interrupted, and the arc broken, the heating coil will, on the current being turned on again, start up automatically and restore the light.

These lamps can be supplied to operate on any direct-current supply from 95 to 500 volts. They take about 4 ampères when starting and about 2·25 ampères when running under normal conditions. If only alternating current is available a rectifier will be required.

Recently the "atmospheric" burner has been

FIG. 64. — Atmospheric Type Mercury Vapour Lamp cooled by Forced Air Draught, with Stand. (Kelvin, Bottomley & Baird.)

modified to make it possible to cool the lamp by a forced air draught.

A motor-fan is attached to the lamp-stand and the air current passes up the hollow lamp handle.

When the lamp is used for local work it is enclosed

FIG. 65.—The Housing of the "Uviator" Mercury Vapour Lamp, cooled by Forced Air Draught.

in a hood and the air current is directed on to the quartz applicator, so that it is kept cool.

The lamp is very convenient when no running water is available, but it is inclined to be a little noisy.

Alternating-Current Burners.—The direct-current is always the current of choice, but there are several alternating-current burners made which can

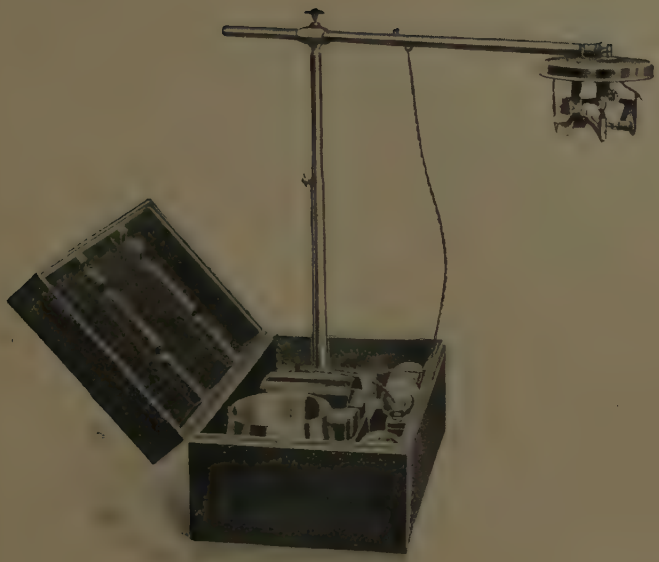


FIG. 66.—Portable Mercury Vapour Lamp ready for use.
(Gallois et Cie.)

FIG. 67.—Portable Mercury Vapour Lamp packed in case.

be connected directly to the alternating-current supply.

These burners all have two positive electrodes:

(1) The "Hanau-Hanovia" is similar to the direct-current burner, but the anodal half of the arc tube is

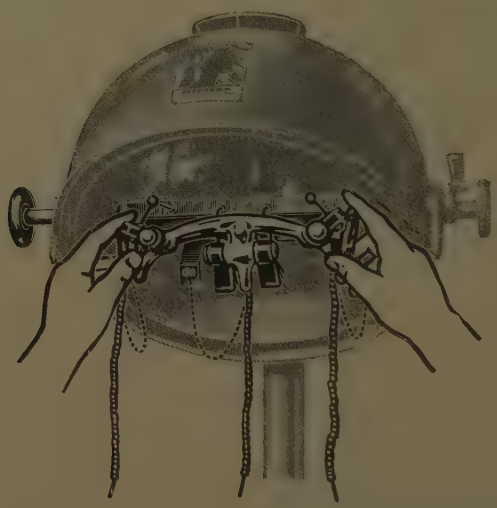


FIG. 68.—Method of inserting the "Silectra" Alternating-Current Quartz Mercury Vapour Burner into its Housing.

split into two parallel anodal chambers, which are on the left-hand side of the burner.

(2) The "Quartz Transparent" is similar to the above.

(3) The "Gallois" burner is V-shaped, the anodal limbs being at the front of the burner and widely divergent; the cathode is at the back, nearest the reflector.

(4 and 5) The "Silectra" and "Ulbrich" burners

are very similar. The anodes form the extremities of an almost straight tube, to the middle of which is attached the cathode, which lies behind and at a lower level.

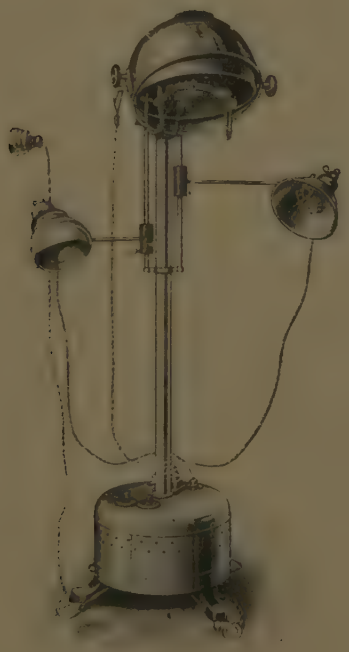


FIG. 69.—"Silectra" Quartz Mercury Vapour Lamp with Infra-Red and Luminous Radiators attached.

The burner has to be tilted upwards, in the horizontal plane, to light, and it is sometimes a little difficult. The "Quartz Dimant" and "Gallois" high-frequency burners can also be used on alternating current.

The Water-cooled Type of Mercury Vapour Lamp

Of this type of lamp, that designed in 1906 by Professor Kromayer, a Berlin dermatologist, is perhaps the best known; it is manufactured in this country by the British Hanovia Company. Different types of

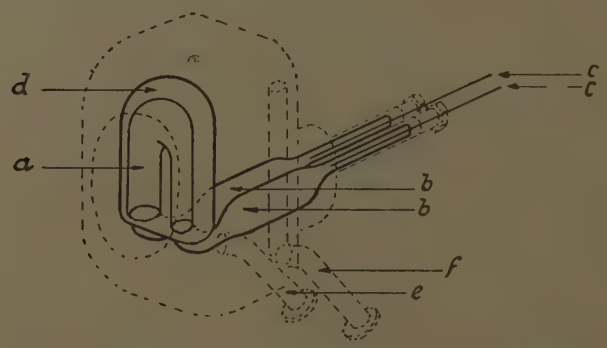


Fig. 70.—Diagram of the "Kromayer" Direct-Current Burner. *a*, Arc Tube—Cathode on the right; *b b*, Electrode Vessels containing Mercury; *c c*, Electrodes conveying Current; *d*, Evacuated Quartz Jacket surrounding Arc Tube; *e*, Inlet Water Tube; *f*, Outlet Water Tube.

lamps have to be used for direct and for alternating current. The lamp for direct current consists of an inverted ∩-shaped arc tube made of fused quartz, having two horizontal polar vessels attached to the lower end of each limb. The alternating-current burner is M-shaped, and has three terminal vessels.

The lumen of the right-hand cathodal limb of the D.C. arc tube is considerably narrowed, and when the arc is first struck the mercury boils at this point.

The arc tube itself is surrounded by a quartz jacket, and this in turn is encased in a watertight metal case

which is fitted in front with a quartz window. Inlet and outlet openings are situated at the back part of the case.

The quartz window itself may be applied directly to the part to be treated, or special quartz applicators may be interposed.

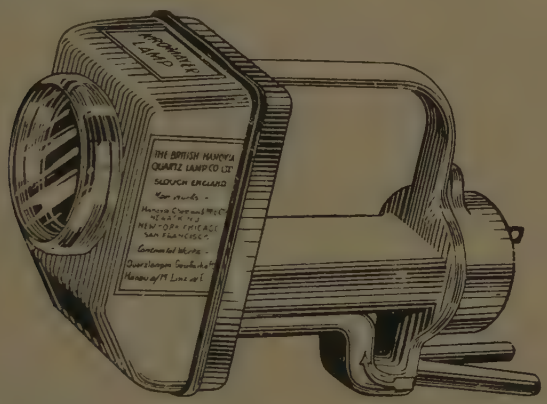


FIG. 71.—Burner Casing of Water-cooled "Kromayer" Lamp.

The lamp is lighted by gently tilting it slightly forwards and then bringing it back to its former vertical position: the tilting brings the mercury in the two limbs together, and the backward movement separates it again, causing the arc to be struck. Shortly after ignition "Kromayer" lamps consume three times their normal running current. The water circulating through the chamber in which the lamp is contained must be clear and pure. This lamp provides a source of the shortest wave-lengths procurable from arc lamps, as the water in the cooling chamber condenses the mercury vapour in the quartz tube, so the ultra-violet rays are not filtered through mercury

vapour, as they are in the case of the air-cooled lamp. This lamp is essentially for local irradiations and is mostly used in the treatment of skin conditions, and therefore more likely to be useful to specialists than to general practitioners.

Kelvin, Bottomley & Baird, the Hewittic Co. and the Quartz Transparent Co. all manufacture a water-cooled mercury vapour lamp very similar to the "Kromayer."

The "Victor" water-cooled burner is a vertical quartz tube with the cathode containing the mercury at the bottom and the tungsten anode at the top.

The shortest wave-length available from the quartz mercury vapour lamp is 1849 Å — owing to the absorption by the quartz. McLennan and Lang, investigating and photographing spark spectra produced with a potential of several hundred volts in a very high vacuum, found that the mercury, iron and copper spectra extended to 1435, 1427 and 1925 Å respectively.

The spectrum of the mercury arc is dominated by the broad line at 1849 Å. It is this line which is most powerful in producing abiotic effects. According to Lyman, fused quartz is often sufficiently transparent to transmit this radiation strongly. Other lines present in the spectrum are 5790 Å and 5770 Å in the yellow, a very brilliant green line 5461 Å, and a faint line 4358 Å in the violet. The resulting illumination is almost entirely due to the green line, and is the nearest approach to monochromatic light that can be obtained.

The mercury vapour lamp gives off practically no

red or yellow rays, so that red objects appear almost black when they are illuminated by it, and the hands and face assume a deathlike, livid, blue appearance.

FIG. 72.—Water-cooled Type "Uviarc" Quartz Tube. (Victor X-ray Corporation, Chicago.)

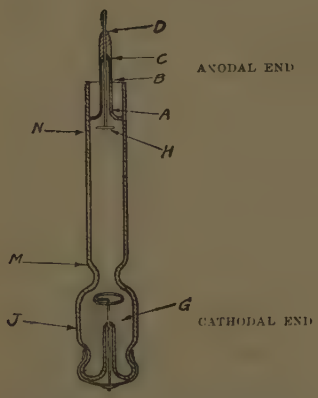


FIG. 73.—The Water-cooled "Uviarc" Quartz Burner.

A, Quartz Stem of Seal Structure; *B*, Connexion of Quartz Stem and Seal Grading; *C*, Connexion of Seal Grading and Seal Coating; *D*, Tip of Seal Coating; *G*, Cathodal Mercury Pool; *H*, Anode Target; *J*, Cathodal Chamber; *M*—*N*, Luminous Portion.

Attempts have been made to remedy the deficiency of red rays by using amalgams of mercury and cadmium, but the results have not been very successful. "Neon" lamps are sometimes used with mercury vapour lamps.

It has been found that the line 2536·7 Å in the mercury vapour lamp is remarkable in its efficiency

FIG. 74.—"Hanovia" Air-cooled Quartz Mercury Vapour Lamp—Alternating-Current Model.

in exciting "resonance," and is particularly potent in producing photo-electric action; further, it has been

FIG. 75.—One of the Lamps of the Authors' Treatment Couch being used for Irradiation of the Scalp. Each lamp is fitted with a Kelvin, Bottomley & Baird "Atmospheric" Burner.

found that it is in this neighbourhood that one finds the greatest therapeutic effect.

Hallwach gives the following table showing relative energy at different wave-lengths :—

Wave-Length	*Relative Energy*
5780 Å	116
5460 ,,	169
4360 ,,	100
4060 ,,	61
3650 ,,	119
3130 ,,	90
2540 ,,	38
2170 ,,	55

It has previously been mentioned that it is essential to provide some means of support for the burner, either a stand or some method of suspension from the wall or ceiling. The stand generally consists of a steel column, which is inserted into a heavy base, provided with casters ; the resistance is often placed at the top of the base ; a bracket arm attaches the hood to the upright column, and this is usually counterweighted.

The authors have designed a special treatment couch. It consists of a couch with two resistances mounted underneath and to which two lamp brackets are fixed. The two lamp housings, which are adjustable in every direction, are supported by the brackets and are counterweighted. For general treatment the range of movement is from three feet downwards.

Either lamp can be used for local treatment, as is seen in the illustration (Fig. 75).

The design obviates the need of an independent stand for each of the two lamps without any loss of

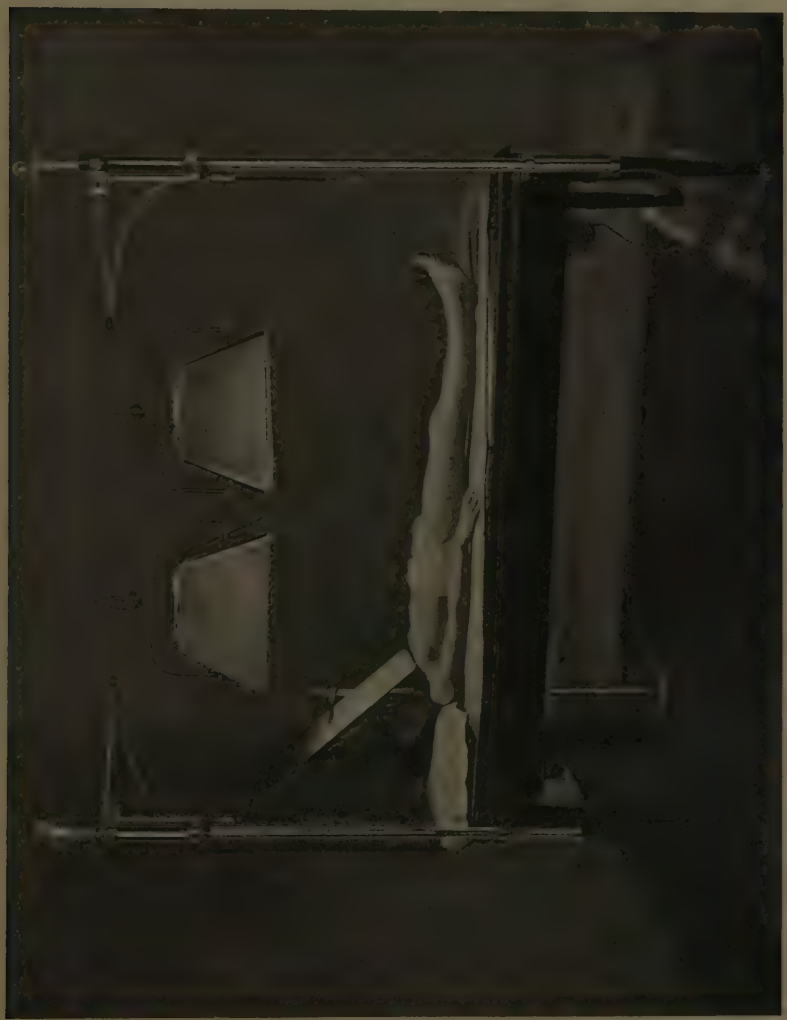


FIG. 76.—The Authors' Treatment Couch, with two Lamps supported by Adjustable Bracket Arms. This method ensures almost uniform distribution of the Rays. The Lamps, which have a wide range of movement, can of course be used singly or together. The Burners, which are of the Kelvin, Bottomley & Baird "Atmospheric" type, can be placed at any distance between 3 feet and 6 inches

FIG. 77.—The same Lamp as illustrated in Fig. 75 being used for Irradiation of the Nose in a case of Hay Fever. The Bracket Arm has been shortened, and the Shield and Nasal Applicators attached to the Housing. A Special Head-Rest, which can rapidly be detached from the chair, is seen in use.

stability. This is an advantage, because the stands and their bases are generally rather cumbersome, and make cleaning operations difficult. Very uniform

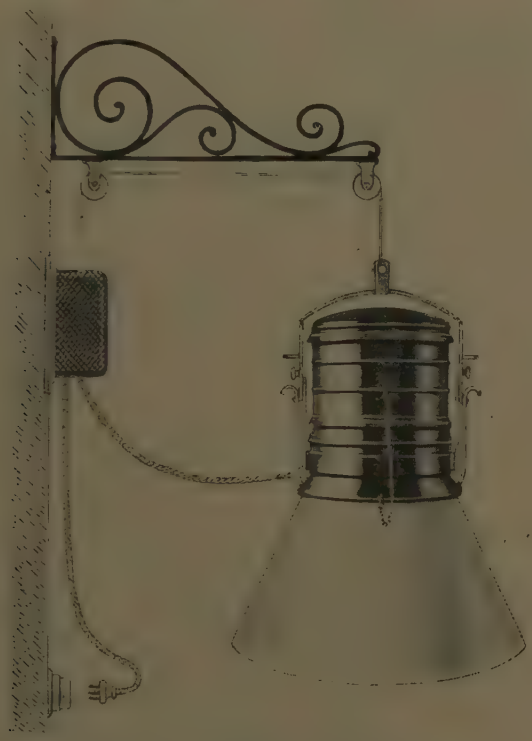


FIG. 78.—Suspension Type of "Hewittic" Air-cooled Quartz Mercury Vapour Lamp, fitted with Automatic Tilting Device.

distribution of the radiation can be obtained with this model.

If the couch is needed for other purposes the lamps can be readily swung out of the way.

The reflecting hoods are of various shapes—hemispherical, cylindrical, parabolic or rectangular—and

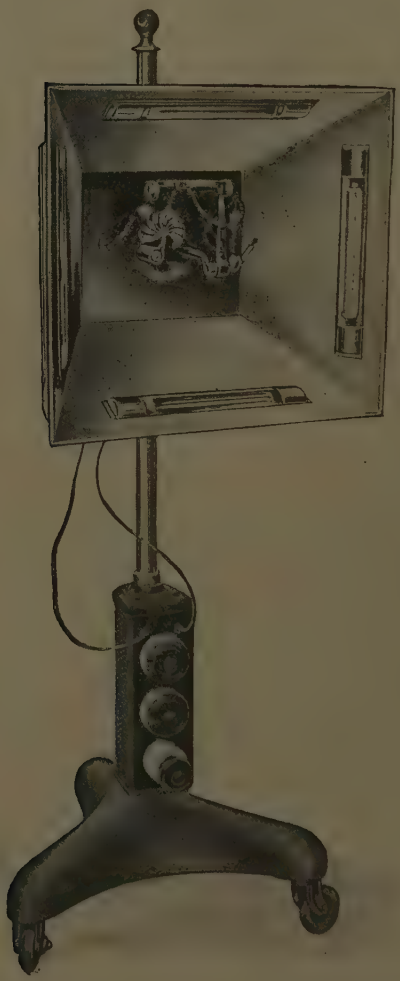


FIG. 79.—"K.B.B." Air-cooled Quartz Mercury Vapour Lamp, Type "E," fitted with Radiant Heaters.

are generally made of aluminium, which is, however, not a good reflector of ultra-violet rays; but this is not of great consequence, as it is the direct rays

FIG. 80.—The Hewittic "Ulviarc" Air-cooled Mercury Vapour Lamp in use. This Lamp is fitted with an Adjustable Parabolic Reflector.

which are most important. It is impossible to get uniform distribution of radiation, the area nearest the arc tube always receiving the greatest amount.

It is necessary to have some means of lighting the lamp; this is generally done by tilting, but there are several automatic burners, such as the "Atmospheric,"

the "Henri George D.C." burner, and the two high-frequency current burners. Moreover one type of "Hewittic" lamp has magnetic tilting. Usually the burner is tilted by a special lever, but in some cases the whole hood tilts. It is generally the anode which is raised to obtain metallic connexion between the two poles. The anode is generally on the left-hand side of the lamp, and the cathode can usually be identified by means of the "cone."

The "Jesionek" type of lamp is generally used for collective treatment, the maximum radiation being horizontal. The "K.B.B." type "E" lamp is provided with four quartz radiant heaters.

The "Hewittic-Levick" lamp has an adjustable parabolic reflector.

All alternating-current lamps need transformers to supply the two halves of the burner with the necessary current, and these lamps are invariably more difficult to light than direct-current burners.

CHAPTER VI

CHEMICAL PROPERTIES OF ULTRA-VIOLET RADIATION

Reactions of Degradation—Reactions of Synthesis—Chemical Methods of Testing the Intensity of Ultra-Violet Radiation—Grotthus' Law—Photosensitization and Inhibition—Photochemistry in Nature—Technical Applications.

THE existence of invisible radiation, beyond the limit of the visible spectrum, having the power of converting silver chloride into metallic silver, was noticed by Scheele as long ago as 1777.

These rays came to be termed "actinic" or "chemical" rays, as they were supposed to be necessary before chemical reactions could take place. This has been proved to be erroneous, however, and it is now known that chemical changes can take place in the presence of all rays of the spectrum, but some so-called photochemical reactions have velocities inversely proportionate to the wave-length of the rays present.

Photochemical reactions may be divided broadly into reactions of degradation—where the original product is broken down—and synthetic reactions—where two or more substances unite to produce a more complex product. Reactions of double decomposition may conveniently be included in the last-named group.

Reactions of Degradation.—The splitting up of

hydroiodic acid into its two elements may be taken as a typical example of the degrading effect of light:

$$2HI = H_2 + I_2.$$

Because of this, hydroiodic acid is always stored in the dark, or in dark-coloured bottles.

If it is kept exposed to light the colourless liquid soon turns to a dark brown hue, owing to the liberation of iodine.

Many other chemical compounds are decomposed by light, even water, but in this case the action is a slow one. Hydrogen peroxide is decomposed much more readily.

Photochemical decomposition of many substances takes place in aqueous solution or in solution in organic solvents.

Rays of wave-length 3330 Å or shorter have been shown by Anderson to convert an aqueous solution of potassium nitrate into nitrite with the liberation of oxygen.

Marmier irradiated sodium sulphate and identified sodium hydrosulphite and sulphur in the degradation products.

Jacquier has found that sunlight or the radiation from a mercury vapour lamp will precipitate metals from solutions of their salts when aluminium plates are suspended in the solutions.

If plates of silver, copper, tin or lead are suspended in water and exposed to ultra-violet radiation, colloidal solutions are formed. A large number of organic compounds are decomposed by radiation. Acetone is broken up into carbon monoxide, ethane and methane.

In the presence of air, chloroform is converted into carbonyl chloride (phosgene) and hydrochloric acid; because of this, chloroform used for anæsthetic purposes should always be kept in the dark, and, as far as possible, the bottle should be full.

Many workers have investigated the effect of light on aqueous solutions of sucrose and other sugars. Sucrose is first converted into glucose and fructose, which are in turn decomposed into aldehydes, ketones and alcohols, and, finally, after prolonged irradiation, to carbon dioxide, carbon monoxide and hydrogen.

Euler and Euler and Ryd have shown that under the influence of the ultra-violet rays aqueous solutions of lactic acid are decomposed into alcohol and carbon dioxide.

Baudisch states that solid calcium lactate is degraded into carbon monoxide, ethane, methane and hydrogen.

The fact that exposure to ultra-violet radiation accelerates the spontaneous decomposition of many commercial explosives has been utilized by Berthelot and Gaudechon as a basis for stability tests.

Reactions of Synthesis.—The formation of hydrochloric acid by the photochemical combination of hydrogen and chlorine is a typical example of a synthetic reaction; an equimolecular mixture of dry chlorine and hydrogen may be kept in a sealed tube in darkness for several weeks without appreciable combination taking place. On exposure to diffuse daylight complete conversion takes place in a few hours, whilst direct sunlight causes the reaction to take place with explosive violence. The light given out by burning magnesium (photographic "flash

powder") also causes explosive combination, as this light is very rich in actinic or short-wave rays. A similar effect is produced by a mercury vapour lamp.

Oxygen is partly converted into ozone (O_3) under the influence of ultra-violet radiation. It has been suggested that ozone is produced in the upper regions of the atmosphere by the action of the sun's rays on the oxygen of the air, and that rain and wind bring this ozone to the earth's surface.

Many organic compounds undergo polymerization when subjected to actinic radiation, two or more molecules uniting to form a larger molecule of the same empirical composition, but having greatly modified chemical and physical properties.

An interesting application of the production of polymers by ultra-violet light is described by Klatte and Tollet, who submitted vinyl chloresters to the action of heat and ultra-violet rays. A solid substance resembling celluloid was obtained from vinyl chloracetate, and a solution which could be used as a lacquer was formed when this was dissolved in a suitable solvent.

According to Plotnikow, vinyl chloride polymerizes under ultra-violet rays of very short wave-length, a substance resembling rubber being formed.

Halogenation, or the introduction of halogens into organic chain compounds, is probably the most valuable technical application of ultra-violet rays to induce or assist chemical reaction. Methane may be chlorinated to give successively methyl chloride (CH_3Cl), methylene chloride (CH_2Cl_2), chloroform $CHCl_3$), and, finally, carbon tetrachloride (CCl_4).

The utilization, on the technical scale, of radiation of this reaction has been extensively exploited in the halogenation of natural gases and liquid hydrocarbons.

Chemical Methods of Testing the Intensity of *Ultra-Violet Radiation.*—This phenomenon of photochemical reaction suggested chemical means by which the intensity of ultra-violet radiations might be determined. The intensity of the radiation may be measured by weighing the quantity of metallic silver produced in a given time from a given amount of silver chloride after a certain length of irradiation. This method may be modified into measuring the amount of blackening of standard photographic paper in a given time.

In Bunsen and Roscoe's actinometer the intensity of ultra-violet radiation is measured by the quantity of hydrochloric acid formed in a given time when the rays are allowed to act on a mixture of hydrogen and chlorine.

King has elaborated a method of estimating the intensity of radiation below 2650 Å by means of carbon tetrachloride, which liberates free chlorine during irradiation. The addition of a potassium iodide solution replaces the chlorine in solution by iodine, which colours the carbon tetrachloride a reddish violet, and the amount of radiation can be estimated from the depth of the coloration.

Moss and Knapp have devised a method which they call the "uroxameter" test, in which they employ aqueous solutions of oxalic acid and uranium acetate and then ascertain the amount of undecomposed oxalic acid by titration with a potassium permanganate solution.

Janet Clark uses the darkening of lithopone paint as a means of estimating the intensity of ultra-violet radiation, lithopone being insensitive to rays above 3200 Å and uniformly affected by rays between 3000 Å and 2300 Å.

Grotthus' Law.—More than a hundred years ago Grotthus propounded the photochemical absorption law, in which he stated that only the rays absorbed are effective in producing chemical change. The law of Ritter, Herschel and Becquerel states that rays of long wave-length exert an oxidizing action as opposed to the reducing action of rays of short wave-length. Rays of wave-lengths shorter than 3022 Å decompose diastase in solution.

We have repeated Schanz's experiment and exposed a dilute solution of egg albumin in a quartz tube for an hour at a distance of 5 cm. from the lamp, and have been able to demonstrate that the albumin reacted like globulin with ammonium sulphate, showing that proteins are rendered less soluble when exposed to ultra-violet radiation under suitable conditions. These rays also partially change chlorophyll dissolved in aqueous alcohol into urobilogen.

Amylase and invertase, the enzymes of malt and yeast, are destroyed by ultra-violet rays, the former more readily than the latter. The rays also destroy the toxicity of strophanthus compounds, and quickly render harmless the venom of the cobra, but have much less effect on antivenomous serum.

The antitryptic effect of human blood is nullified by ultra-violet radiations.

Photosensitization and Inhibition.—Certain bodies

may act as sensitizers in a large number of photochemical reactions, promoting reaction or increasing its velocity. Other substances act as inhibitors or decelerators.

The ordinary photographic plate is much more sensitive to light of short wave-length than to light in the red end of the spectrum, which causes a bright red object to appear much darker in a photograph than a dark blue object, giving a false impression of the respective colours.

Colour-sensitive plates, which are equally susceptible to both the red and blue ends of the spectrum, are made by the addition of certain compounds.

Vogel observed, as long ago as 1873, that photographic plates could be made sensitive to other colours besides blue and violet by the incorporation of certain colouring matters, and Waterhouse, in 1875, showed that eosin rendered a plate sensitive to yellow and green.

In 1856 Greville Williams prepared the blue colouring matter cyanine, and in 1875 Vogel discovered that this compound acted as a photographic sensitizer for the red.

In 1903 Miethe first used the isocyanine colouring matters as sensitizers and obtained much better results than with cyanines, which are inclined to give irregular results.

Pope and his contemporaries have introduced many new photographic sensitizers within recent years, and plates can now be obtained which are sensitive to the whole range of the solar spectrum.

In some photochemical reactions the presence of

water or water vapour acts as a sensitizer, whilst in other cases it partly or entirely inhibits the reaction.

The halogens, mercury and zinc oxide, often act as sensitizers.

It has been found that hydrogen and oxygen alone do not react at ordinary temperatures in the presence of ultra-violet rays, but the addition of mercury causes immediate combination.

The photochemical decomposition of carbon dioxide is inhibited by the presence of even a trace of water vapour, whilst water is essential for the combination of hydrogen and chlorine under the influence of visible light. The decomposition of potassium nitrate in aqueous solution is auto-inhibited by the nitrite liberated in the reaction.

Photochemistry in Nature.—Photochemical reactions play an important part in plant metabolism.

The living plant inhales carbon dioxide from the air, and under the influence of sunlight this reacts with water to form formaldehyde, which is subsequently polymerized to carbohydrates.

This theory was first postulated by Bayer, in 1870. The chlorophyll of the leaf and inorganic bodies derived from the soil probably act as photocatalysts.

Baly and his co-workers have repeated the photosynthesis of formaldehyde in the laboratory.

These investigators have submitted water, through which was passed a stream of carbon dioxide, to ultra-violet radiation, and have detected formaldehyde in the resultant solution. Rays of 2000 Å cause the production of formaldehyde and those of 2900 Å polymerize the aldehyde to reducing sugars.

Ferric hydroxide, malachite green and chlorophyll all catalyze the formation of formaldehyde, while calcium carbonate assists in the polymerization of formaldehyde to form sugars.

$$CO_2 \times H_2O \rightarrow \underset{\text{Formaldehyde}}{HCHO} + O_2$$

$$6HCHO \rightarrow \underset{\text{Fructose, glucose, etc.}}{C_6H_{12}O_6}$$

$$2C_6H_{12}O_6 \rightarrow \underset{\text{Sucrose, maltose, etc.}}{C_{12}H_{22}O_{11}} + H_2O$$

$$nC_6H_{12}O_6 \rightarrow \underset{\text{Starch}}{(C_6H_{10}O_5)\ n} + nH_2O$$

The natural synthesis of proteins by the living cell has attracted much attention among biologists and biochemists.

Fischer, in his epoch-making researches on the synthesis of proteins, succeeded in building up many polypeptides closely related to proteins from amino-acids, and has indicated the possibility of synthesizing proteins by a similar method.

The plant obtains its supply of nitrogen from the nitrates and nitrites of the soil, but many are also able to assimilate nitrogen and oxides of nitrogen from the air.

According to Baly, Heilbron and Stern free ammonia plays an important part in plant metabolism; they identified methylamine and nitrous and nitric acid in the products obtained after irradiating solutions of ammonia and carbon dioxide with a quartz mercury vapour lamp.

The photochemical reaction between "activated" formaldehyde and potassium nitrite produces the

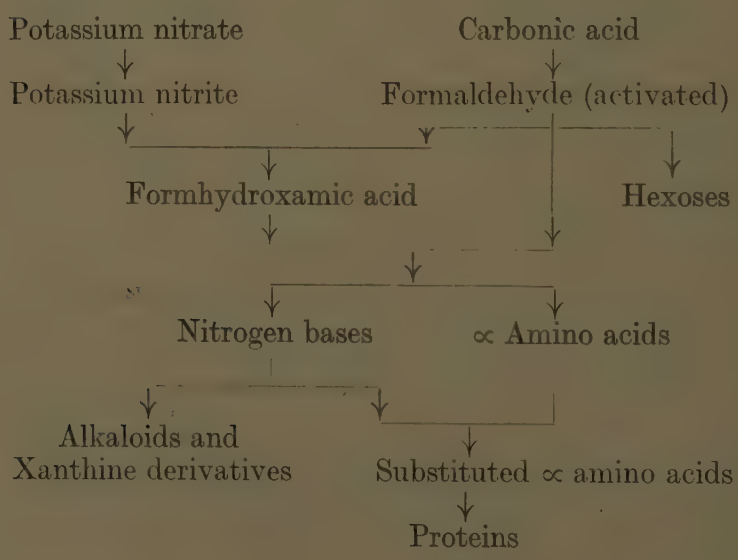
potassium salt of formhydroxamic acid $\begin{matrix} HCOH \\ \| \\ NOK \end{matrix}$, and this is probably the first step in the production of nitrogen compounds in the plant.

From this substance amino-acids and proteins are most likely synthesized.

Baly, Heilbron and Hudson have obtained definite evidence of the formation of amino-acids from formaldehyde and nitrate, and they have also isolated alkaloidal bases.

They have identified pyridine, piperidine and methylamine in the products of the photochemical reaction between ammoniacal cupric carbonate and carbon dioxide.

Baly and his co-workers suggest the following scheme as an indication of what probably occurs in the plant:



Technical Applications.—An interesting use of ultra-violet radiation is for testing the fastness of various dyestuffs. Previously when it was desired to make experiments in this connexion it was customary to send fabrics for exposure for one or two years to the tropics, or to attach them to the masts of ships. With ultra-violet radiation, after very short exposures, their fastness or otherwise can be demonstrated.

We found on exposing cotton fabrics dyed with direct cotton colours that fading commenced very rapidly indeed, and that considerable bleaching had occurred with exposures varying from sixty to ninety minutes.

The "Fadometer" can also be used for testing the permanency of inks, paints and enamels.

Certain leather manufacturers found that "patent leather" exposed in the process of manufacture to sunlight was greatly improved in quality. This, however, incurred great difficulties, as the leather had to be protected from the slightest shower.

Now mercury vapour lamps are used to illuminate special airtight chambers where the leather is dried in a few hours.

At a local tannery they have also found that patent leather exposed to ultra-violet radiation becomes more deeply coloured and glossy.

CHAPTER VII

PHYSICAL PROPERTIES OF ULTRA-VIOLET RAYS

Detection of Ultra-Violet Radiation—Spectroscopic Examination of Radiation—Methods of Determining the Intensity of Radiation (Chemical, Thermal, Photometric, Electrical) —Photo-electric Effect—Absorption of Ultra-Violet Rays—Glasses—Reflection of Ultra-Violet Rays—Fluorescence

THE presence of ultra-violet rays can always be proved by their power of blackening silver chloride, and also by their action on photographic plates and paper. In their presence willemite gives out a brilliant green fluorescence. We found that this green fluorescence immediately disappeared when a thick sheet of plate glass was placed between the willemite and the source of the rays, proving that the visible rays were not responsible for the phenomenon. We also noticed that when long rays from an electric torch were directed on to the willemite the fluorescence was again not excited; but it is produced by the invisible ultra-violet rays passing through a special filter of oxide of nickel.

To study ultra-violet radiations it is necessary to make use of a spectroscope in which the prisms and lenses are of fluorite or quartz, since ordinary glass prisms and lenses absorb all the waves of short length. Photographs of emission and absorption spectra can

be made with this instrument. Air absorbs rays of lower wave-length than 1700 Å, so spectrographs of the extreme ultra-violet region must be taken in

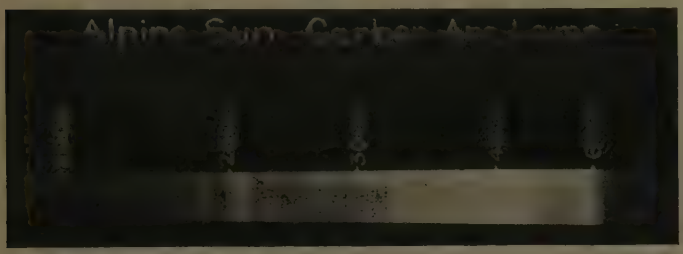


FIG. 81.—Spectrum of Impregnated Carbon Arc.

vacuo. In studying spectra it is advantageous when possible to make use of a diffraction grating, as then

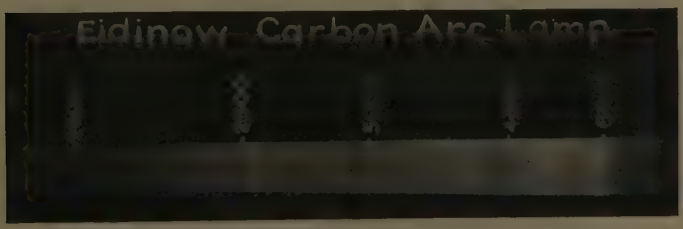


FIG. 82.—Spectrum of Long-Flame Carbon Arc Lamp with Impregnated Carbons.

not only a pure spectrum, but a uniformly disposed one (*i.e.* one in which all wave-lengths are equally separated), is obtained.

Methods of Determining the Intensity of Radiation:

1. *Chemical*—

(*a*) The effect of rays on silver chloride or sensitized paper.

Erythema Dosimeter.—This apparatus has been devised by Dr Keller to measure the amount of radiation, which is active in producing erythema, given off from any source. Different portions of a single strip

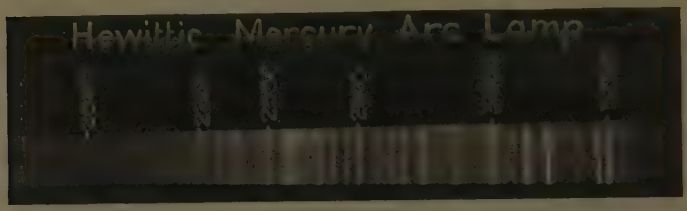


FIG. 83.—Spectrum of Vacuum Type Quartz Mercury Vapour Lamp.

of special photographic paper are simultaneously exposed to the rays at the same distance at which it

FIG. 84.—Spectrum of Atmospheric Type Quartz Mercury Vapour Lamp

is desired to expose the patient: (1) without any cover; (2) under Uviol glass; (3) under special glass which completely absorbs the erythema-producing rays.

The uncovered portion of the paper is allowed to become as dark as a special blackened test surface; the number of seconds which this takes is noted. The paper is then removed, and the shades of the

portions (2) and (3) are compared with specially prepared tables. From these the ultra-violet intensity is obtained.

(*b*) *Actinometers.*—Bunsen and Roscoe's actinometer based on the amount of HCl formed on irradiating a mixture of hydrogen and chlorine.

FIG. 85.—Dr Keller's Erythema Dosimeter.

(*c*) Bleaching power of radiations on acetone methylene blue solution (Webster, Eidinow and Hill).

(*d*), (*e*) and (*f*) The Carbon tetrachloride, Uroxameter and Lithopone tests mentioned in Chapter VI.

(*g*) Bordier's chromoactinometer consists of paper tinted yellow, with a 20 per cent. solution of potassium ferrocyanide and a graduated series of permanent tints of known value. When the test paper is exposed to ultra-violet radiation it becomes a yellow-ochre colour, and this paper is compared with the standard tints.

(*h*) Filter paper soaked in a solution of paraphenylenediamine nitrate turns a violet colour when exposed to ultra-violet rays.

(*i*) The new Levy-West ultra-violet pastilles consist of small discs of thin cardboard, having the white side coated with a material which is sensitive only to ultra-violet rays between 2300 and 3800 Å, and which responds equally to these rays.

On the reverse side the discs are dark grey in colour

FIG. 86.—Case containing Levy-West Ultra-Violet Pastilles, "Vitaglass" Filter and Tint Cards giving Units of Dosage.

and covered with an adhesive which can be made to stick by damping it.

The white side of the disc turns varying shades of light yellow, corresponding with the length of exposure. A tint card is provided, showing average tints expressed in units of 1, 2, 4, 6, 8, 12—tint 1 being an average first dose.

The proportion of radiation having a wave-length shorter than 2900 Å can be determined by exposing two pastilles simultaneously, one unscreened and the other covered by the "Vitaglass" slide, which is provided.

2. *Thermal*—

(*a*) Different types of pyrheliometers or actinometers can be used. Perhaps the best known are those which have been devised by Violle, Pouillet, Ångström, Abbot, Michelson and Callendar.

Pouillet's Pyrheliometer.—A surface of known size is exposed to the radiation, and the amount of heat imparted by it to a given quantity of mercury in a certain length of time is noted. After allowance has been made for loss due to radiation, the quantity of heat received in a certain time is obtained by multiplying the specific heat of the body by its mass, and also by the rise in temperature.

Crookes' Radiometer.—This little apparatus, so often seen in opticians' windows, can be used for the measurement of the intensity of incident radiations, a relation existing between this and the revolutions per second of the vanes of the radiometer.

Ångström's Pyrheliometer.—Two identical strips of thin metal are used, one being kept in the dark, and the other being exposed to radiation. The strips are connected by a galvanometer, the needle of which is deflected. This deflection is reduced to zero by passing an electric current through the shaded metal strip; this current equals in intensity the radiation falling on the exposed strip.

(*b*) *Rubens' Thermopile.*—An electric current is produced when metal couples such as iron or

copper and constantin are heated by being exposed to radiation. A galvanometer records the current, and from this measurement the intensity of the radiation can be obtained.

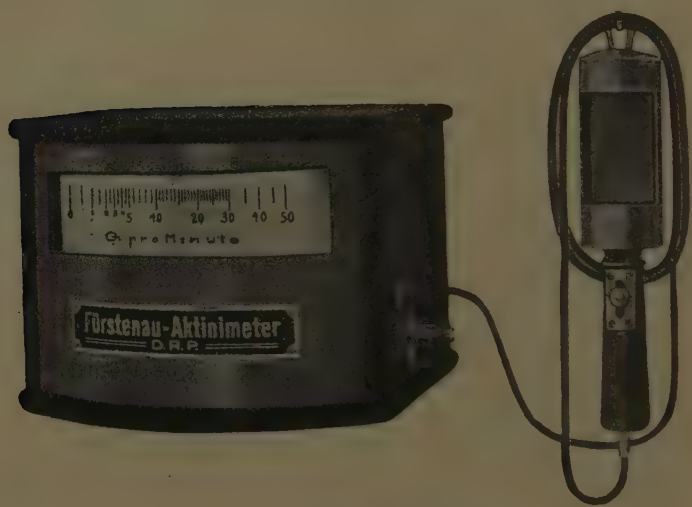


FIG. 87.—The Furstenau Actinometer.

(*c*) *Langley's Bolometer.*—The rays are directed on to a thin strip of blackened metal; radiant energy is absorbed, raising the temperature of the strip. This alters its electrical resistance; the intensity of the incident radiation can thus be measured.

(*d*) *Fürstenau's Actinometer.*—This consists of two parts: a selenium cell fitted with a spring shutter and an instrument for registering the intensity of the radiation. The electrical resistance of the cell is modified when ultra-violet rays fall upon it; but heat rays also

influence it. There is a graduated scale marked from 0 to 50. The point 40 on the scale corresponds to an erythema dose.

3. *Photometric.*—In this method the spectrum of the radiation under examination is compared with one of known source and strength.

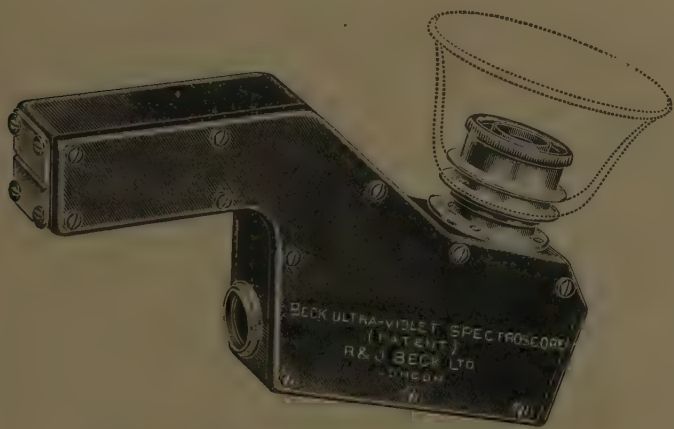


FIG. 88.—The Beck Ultra-Violet Spectroscope.

A spectroscope enables a detailed examination to be made of the radiation given off by a substance in the incandescent state. For use with ultra-violet rays it consists of four essential parts:

(*a*) A narrow slit through which the radiation passes;

(*b*) A small telescope, called a collimator, which renders the rays parallel;

(*c*) A quartz prism to produce dispersion of the rays;

(*d*) A fluorescent screen, which transforms the invisible ultra-violet radiation into visible light.

Photographs of the spectrum may be taken by

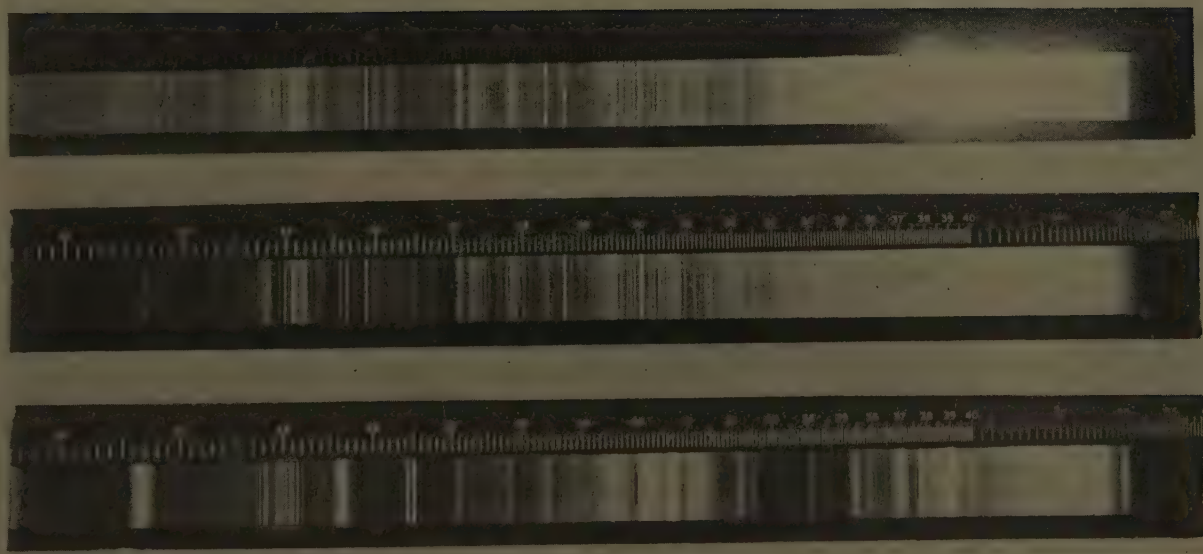


FIG. 89.—Spectrographs.

A, Of the Carbon Arc; B, Of an Arc with Carbons cored with Molybdenum and Tungsten; C, Of an Arc with Aluminium Electrodes. (From *Modern Science*.)

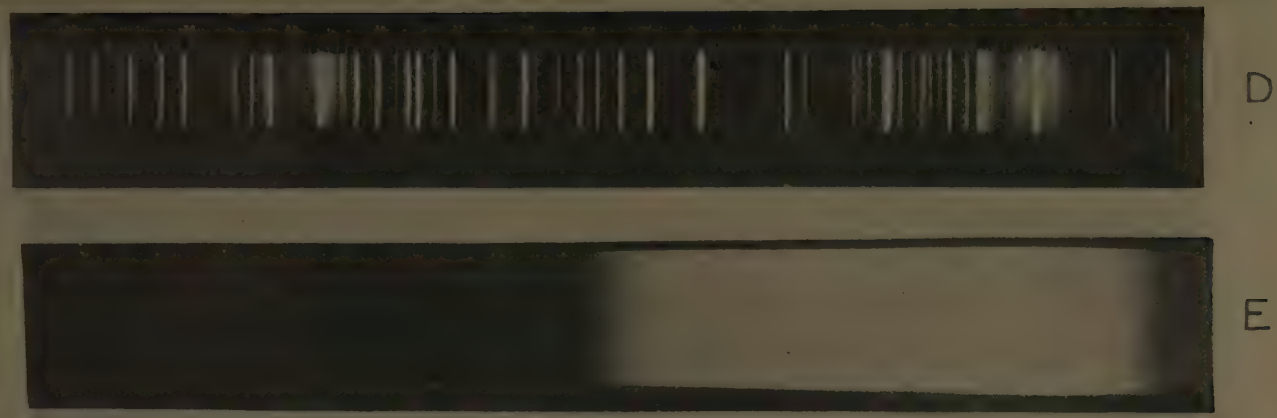


FIG. 90.—Spectrographs.
D, Of the Quartz Mercury Vapour Lamp; E, The Solar Spectrum. (From *Modern Science.*)

substituting suitably screened photographic plates for the fluorescent screen.

Another method of determining the relative intensity of ultra-violet rays consists in passing the radiation through a Chance's ultra-violet filter and then through a piece of uranium glass. The last-named fluoresces when actinic rays are present.

4. *Electrical.*—This method is based on the phenomenon that if metals are exposed to rays of certain wave-lengths negative electrons are emitted. If the metal is charged positively before illumination it remains charged indefinitely. A metal plate tends to become positive on illumination, as it is giving off negative electrons. After a while it would become so strongly positive that it would tend to attract back the negative electrons. If ultra-violet rays fall on the polished surface of a zinc plate negative electrons are shot off. If a fine metallic gauze, positively charged and fitted to a gold-leaf electroscope, is placed in front of it the electrons will be caught and measured, and the intensity of the illumination may be determined.

Dr Rosselet, who is at present in charge of the electro-therapeutic department of the Cantonal Hospital, Lausanne, recently explained to us the apparatus with which he made most of his observations on the intensity of natural ultra-violet radiation. The apparatus consists of a zinc sphere, 2 cm. in diameter, which has been dipped into hydrochloric acid, and then amalgamated by dipping into mercury. The sphere is situated in the long axis of a cylinder of brass which is blackened on its inner surface, the sphere being kept in position by a wire, which is

attached to it at one end, and to an Elster and Geitel's electroscope at the other. The wire passes through an amber button in the centre of the closed end of the cylinder. The sphere is charged with negative electricity and discharged under the action of ultra-violet radiation. The rate of discharge is proportional to the intensity of the incident radiation.

We made an electroscope with English gold-leaf attached to a copper wire, which passed through an insulated cork, and was attached to a polished zinc plate, which was negatively charged from ebonite. On irradiation with the mercury vapour burner the leaves, which were separated when charged negatively, gradually came together again, proving the discharge of the zinc plate of its negative electricity. This phenomenon is known as the photo-electric effect of radiant energy.

Griffith and Taylor have recently devised a photometer for measuring the intensity of ultra-violet radiation. It consists of a photo-electric cell and a gold-leaf electroscope. The cell is made of glass—except at one end, where there is a flat quartz window. The cell is evacuated of air and then filled with argon or hydrogen at a pressure of 3 mm. of mercury.

The cathode consists of a thin disc of cadmium attached to a copper support, which is carefully insulated and is attached to the terminal of the electroscope. A short distance in front of the cathode is a fine wire grid, the anode, which is earthed. The electroscope is charged with a negative charge of about 200 volts, which causes the leaves of the electroscope to separate.

When in use, ultra-violet rays enter the quartz window, pass through the wire grid and act on the cadmium plate, causing it to give off negative elec-

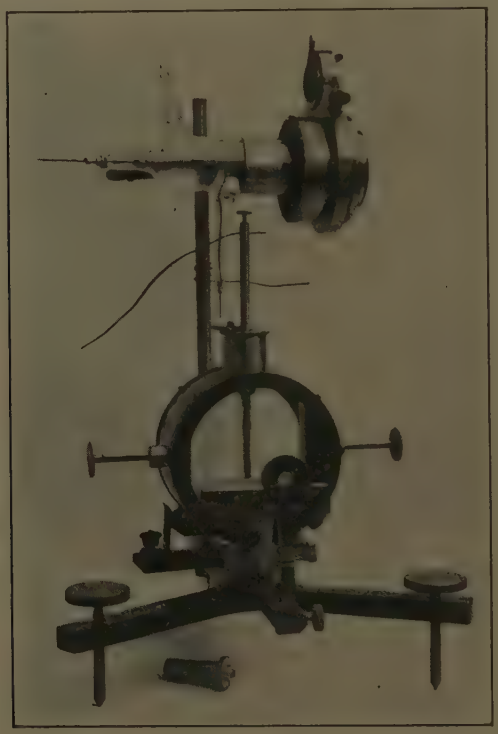


FIG. 91.—General view of Griffith and Taylor's Apparatus for Measuring the Intensity of Ultra-Violet Radiation.

trons, so that the electroscope which is attached to the cathode is gradually discharged. The intensity of the ultra-violet rays is directly proportional to the rate of discharge. In making measurements the exact distance of the photometer from the source of radia-

tion has, of course, to be taken into account. Wave-lengths greater than 3500 Å do not influence cadmium photo-electrically, and the quartz window is opaque to most wave-lengths below 2000 Å, so that the

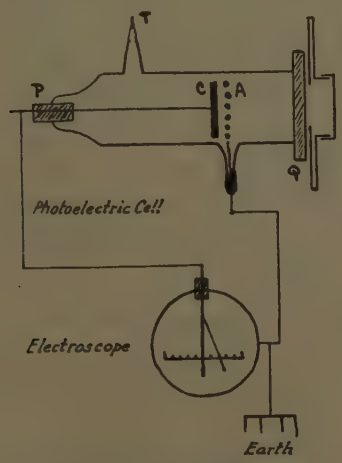


FIG. 92.—Diagram of Griffith and Taylor's Cadmium Photo-Electric Cell.

A, represents Anode, consisting of a Wide-Mesh Grid of fine Wire about 3 mm. from Cathode; C, Cadmium Electrode attached to Copper Support; P, Quartz Bush through which Copper Wire passes; Flat Quartz Plate screened by Adjustable Diaphragm; T, Point for Evacuation, Introduction of Argon and, finally, Sealing of Cell.

photometer is sensitive only to ultra-violet rays between these two wave-lengths.

Every substance has a critical or threshold wave-length, below which, even in the case of X-rays, electrons are given off. Above this critical wave-length no electrons are given off. Wave-lengths below 3000 Å generally bring about this effect. In some metals the

critical wave-length is very large, and even visible light will cause the emission of electrons. The critical wave-length of sodium is 3400 Å, potassium, 4400 Å, rubidium, 4800 Å. In the case of the latter a piece of heated glass tubing will cause it to give off electrons. If the substance is in chemical combination it is still subject to this phenomenon, and the critical wave-length remains unchanged.

In the case of solids, there are supposed to exist unattached and wandering electrons interspersed between the molecules. These can be ejected by heat. They are the important agents in thermo-electricity, and in the conduction of electricity and heat. A good conductor is one which contains many such free electrons. Metals are of this class. Non-metals, such as glass, paraffin-wax, porcelain, ebonite, etc., have very few free electrons, and are therefore insulators.

Electrons are very small particles of electricity, each equal to one two-thousandth part, approximately, of the hydrogen atom. They can be weighed and measured. They all have the same mass, diameter and electric charge, being composed wholly of negative electricity. They rotate round the proton, or positive nucleus, much in the same way as planets round their sun, and thus by their varying numbers and arrangement give rise to atoms of different elements.

When a metal is acted upon by rays smaller than its critical wave-length, electrons are emitted not only from the surface of the metal, but also through its substance, and even from the opposite side if the metal is not too thick. There is a diversity of opinion

as to whether the emission of electrons is evenly distributed in all directions, or whether they are given off in exactly the same direction as the incident rays.

The number of electrons given off is in direct proportion to the intensity of the light. The velocity of the electrons is affected only by the wave-length of the rays, being greater the shorter the wave-length. There is a uniform velocity of the emitted rays for any given wave-length.

On comparing the intensity of the incident and emergent electrons given off by films of varying thicknesses under ultra-violet irradiation, Stulmann proved that the maximum emission energy of the photo electrons was about 40 per cent. greater when they left the emergence side than when they left the incidence side in the case of very thin films. With thick films the reverse effect was obtained.

As the photo-electric phenomenon takes place when substances are in chemical combination, if certain salts are applied to the skin, such as zinc salts, electrons would be given off, some of which would penetrate the skin. It would be interesting to know whether the absorption of the ultra-violet rays themselves or the actual electrons given off have most influence on the biological effect.

All metallic substances are photo-electric, and also many non-metallic substances, such as sulphur, paraffin, aniline dyes, etc.

Drina investigated the photo-electric effect of numerous inorganic compounds, and found that when a metal can combine with another element in two ways that compound in which the metal has the lower

valency has the bigger photo-electric effect, and also, in the case of halogens, the photo-electric effect increases as a heavier halogen atom is substituted for a lighter.

Gases are also subject to this phenomenon, and on this is based Hertz's discovery, in 1887, that if the two pole plates of a spark coil are so adjusted that a current will just not pass between them, and ultra-violet rays are directed on to the gap, a spark will pass, owing to the formation of electrons from the metal spheres of the pole plates, and also to the ionization of the intervening air gap. Heat, X-rays and radium emanations have the same effect.

Hughes found that the critical wave-length for air = 1350 Å.

It is interesting to note that ions from ionized gases can be filtered out of the gas by being passed through cotton-wool. In liquids, where the penetration is deeper, the electrons do not escape so easily, so besides emission of electrons there is also increased conductivity of the solution.

Temperature has no effect on the photo-electric effect. In the case of the alkali metals polarization of the rays increases the effect when the vibrations in the rays are vertical to the metal acted upon. If they are horizontal they have no influence whatsoever. The photo-electric effect is probably directly proportional to the amount of ultra-violet rays absorbed (Grotthus' law). The phenomenon of photo-electric fatigue is interesting. After radiation has been allowed to fall on a substance for some time the number of electrons emitted by the substance gradually decreases. If the substance is then given a rest and

radiation again commenced, the original number will again be given off. This fact can be proved by means of the gold-leaf electroscope.

Absorption.—When light rays are incident on the

FIG. 93.—The "Hilger" Ultra-Violet Spectroscope.

surface of a medium some are reflected and some are absorbed :

Absorption = the ratio of the amount absorbed to the amount incident.

Reflection = the ratio of the amount reflected to the amount incident.

The sum of these = 1.

Unit increase in thickness of a medium reduces the intensity of a radiation by a ratio which is constant.

Most substances become increasingly opaque to ultra-violet radiation as the wave-length decreases. and this absorption of the shorter rays makes their study particularly difficult. It is thought that oxygen causes air to be opaque to wave-lengths shorter than 1850 Å. Nitrogen, on the other hand, is quite transparent to ultra-violet rays, and so also is hydrogen. Ozone absorbs these rays strongly. It is present in very high atmospheric regions where it helps to shield the world from excessive ultra-violet radiation. Water vapour, dust particles and smoke all absorb the rays, and this is the reason why the sun's rays in our large cities are so weak in the ultra-violet portion of the spectrum. In winter these rays are often entirely absent after the sunlight has been filtered through a layer of water vapour and smoke. Leonard Hill says that "on a clear day 75 per cent. of the sun's energy which reaches the earth's atmosphere arrives at an altitude of 18,000 feet, and only 50 per cent. at sea-level. Of course the amount is still further reduced by absorption of particles of dust and water vapour which surround large cities."

When ultra-violet radiation is transmitted through clear tap water a fair amount of radiation is absorbed, but this is not so with distilled water. Ordinary tap water 10 cm. in depth absorbs all rays shorter than 2350 Å; but bacteria can be killed in water at as great a depth as 30 cm.; water, however, strongly absorbs the infra-red rays.

Absalom concluded that transparency to ultra-violet rays associated with colour is more commonly found with the colloidal metals than with ordinary coloured salts or aniline dyes. Generally, fluorescent solutions and solids are opaque to the rays. By using ultra-violet radiation it has been found possible to detect in their absorption spectra quantities of cocaine as small as 1 in 200,000, and atropine at a strength of 1 in 2000.

Solutions of peptone, amino-benzoic acid, tyrosin, leucin, and phenylalanin are not penetrable by ultra-violet rays at all. Blood absorbs all rays shorter than 4500 Å, and has absorption bands at 5400 Å and 5700 Å.

Fluorite is the most transparent solid to the actinic rays that has been found, as it transmits as far as 1250 Å.

Quartz comes next to fluorite in transparency. There is, however, a big difference between fused and crystalline quartz, the latter being much more transparent. Quartz absorbs in the region of 1850 Å, but there is considerable variation with different specimens. Celluloid and gelatin are transparent to near and middle ultra-violet radiations, but mica absorbs all wave-lengths below 3100 Å.

"Windolite" consists of acetocellulose spread in a thin film on a fine wire mesh; it transmits to 2320 Å.

Glasses.—The transparency of various glasses to the rays differs considerably: most clear glasses transmit wave-lengths of 3500 Å, but transmission below this level is very variable. The thickness of the glass and its chemical composition are both important

factors. The glasses which are most absorbent are those containing metals of large atomic weight.

It is not correct to say that glass does not transmit ultra-violet rays. It is, however, not transparent to the rays of most value. A quartz spectrograph is the simplest means of studying the transparency of glasses.

The permeability of window glasses is interesting.

Luckiesh gives the following table for different glasses 2 mm. in thickness:

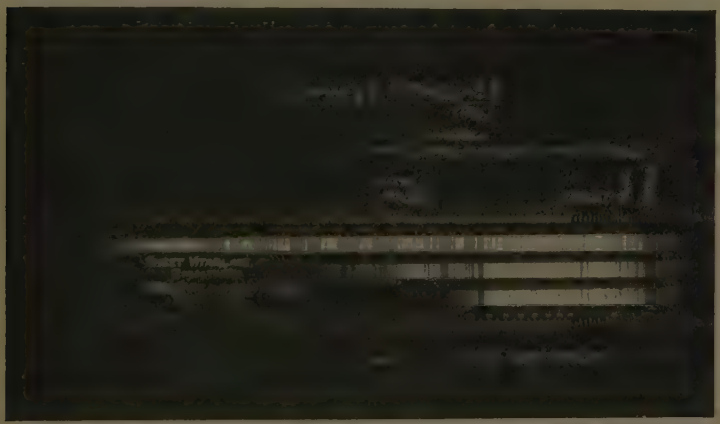
Type of Glass	*Absorption Limit*
Common Glass	2950 Å
Light Crown	2950 ,,
Extra Light Flint	2980 ,,
Medium Crown	3000 ,,
Light Flint	3050 ,,
Medium Flint	3150 ,,
Extra Dense Flint	3350 ,,
Schotts' Heavy Flint	3400 ,,

Ordinary window glass absorbs rays below 3300 Å, so pigmentation does not occur under glass, as rays about 3000 Å are most active in producing pigmentation.

Best Crown Glass absorbs very strongly from 3100 Å.

Recently F. E. Lamplough, M.A., has succeeded in making a new glass called "Vitaglass." This special glass, which contains a large proportion of quartz, and other ingredients not present in ordinary glass, has the property of transmitting rays up to 2750 Å; it is thus freely transparent to all the ultra-violet rays which occur in sunlight. This discovery of a comparatively cheap material which transmits all the

natural ultra-violet radiation is of outstanding importance, especially as "Vitaglass" (when bought in quantity) is less expensive than the cheapest varieties of plate glass. When the sun is shining all the beneficial effects of natural sunlight can now be easily



A
B
C

FIG. 94.—Illustration showing the Transmission of Ultra-Violet Rays by "Vitaglass."

A, Spectrograph of the Iron Arc without filtration; B, Shows that "Vitaglass" transmits the Vital Ultra-Violet Rays to the extreme limit (wave-length 2900 Å) of the Sun's Spectrum; C, Shows that the Vital Rays are completely obstructed by ordinary Window Glass.

enjoyed in warmth and in privacy, in a room having windows or roofs glazed with "Vitaglass."

This makes its use in hospitals, sanatoria, convalescent homes, schools, nurseries, etc., especially important. It has recently been proved that when sunlight is transmitted through either quartz or "Vitaglass" the lethal effect on infusoria is exactly the same. Dr Leonard Hill has recently confirmed, in his Royal Institution lectures, the transparency of "Vitaglass" to 2750 Å.

"Vitaglass" of 15 oz. weight transmits approximately 65 per cent. of the incident radiation with wave-lengths between 3100 and 2900 Å.

In actinotherapy and arc welding, glasses which cut

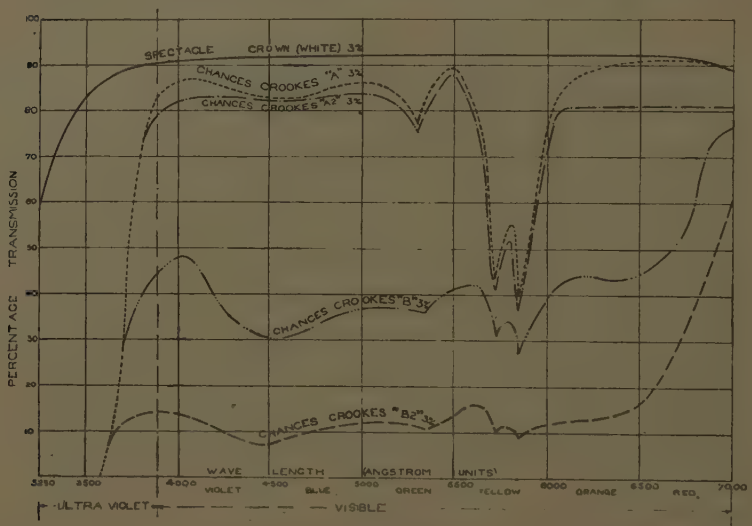


FIG. 95.—Graphs showing the Transmissions of Chance's Spectacle Glasses.

off the ultra-violet rays are very important. Well-known varieties are :

(1) Euphos Glass, and

(2) Fieuzal Glass No. 5.

Other glasses absorb the ultra-violet rays and also most of the infra-red. The best-known are :

(3) Chance's Crookes A Glass, which is a faint neutral shade and transmits 86 per cent. of daylight. Crookes A Glass is practically colourless except for a faint bluish tinge.

(4) Chance's Crookes A_2 Glass transmits 78 per cent. of daylight.

(5) Chance's Crookes B Glass is a stronger neutral colour and transmits 46 per cent. of daylight.

(6) Chance's Crookes B_2 Glass transmits only 20 per cent. of daylight.

(7) Saniweld Glass.

(8) Noviweld Glass transmits less than 1 per cent. of ultra-violet rays and 1-3 per cent. of the infra-red.

(9) Pfund lenses consist of Noviweld Glass which has been gold-plated and covered with a transparent cover-glass; their properties are due to reflection of the infra-red and ultra-violet rays rather than to absorption. They appear like a gold mirror, but their transparency for luminous rays is exceedingly good, because, owing to their property of reflection, a light-tinted Noviweld Glass can be used.

Glasses which transmit only ultra-violet rays:

(1) Wood's Filter.

(2) Chance's Ultra-Violet Glass transmits only rays between 2870 and 4270 Å, with the maximum transmission between 3300 and 3900 Å.

(3) Oxide of Nickel Glass.

(4) Wratten Filter No. 18.

Other glasses are permeable only to the near ultra-violet rays:

(1) Gallois Special T.O. Glass, which is transparent as far as 2900 Å.

(2) Clear "Uviol" Glass (Schott), when 1 cm. thick, transmits 50 per cent. of wave-length 3050 Å, and when 1 mm. thick 50 per cent. of wave-length 2800 Å.

(3) Blue "Uviol" Glass 2 mm. thick, transmits as far as 2850 Å.

Fluorescent screens are made generally of barium platinocyanide or uranium glass.

Pyrex Glass a few millimetres thick transmits to 2900 Å.

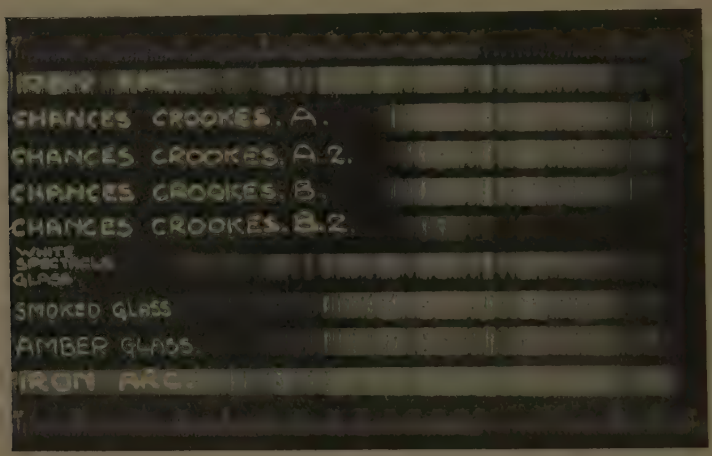


FIG. 96.—Spectrographs showing the Transmission of Chance's Crookes Spectacle Glasses. They transmit very little of the Spectrum below 3900 Å.

Crookes A Glass 1·79 mm. thick absorbs all rays below 3450 Å.

Crookes B Glass 1·93 mm. thick absorbs all rays below 3500 Å.

Euphos Glass 1·95 mm. thick absorbs all rays below 4000 Å.

Fieuzal Glass 2·13 mm. thick absorbs all rays below 3500 Å.

Saniweld Glass 1·82 mm. thick absorbs all rays below 5000 Å.

One mm. thickness of skin absorbs rays shorter than 3600 Å; 2·5 mm. are opaque to indigo and violet 4358 Å.

Lenku, Ganni and Busk showed that light filtered through potassium bichromate solution, transmitting only red, orange and yellow rays, caused an impression on an isochromatic plate after traversing the hand. This did not take place when blue and violet rays were used, an ammoniacal solution of copper

FIG. 97.—The "K.B.B." Microscope Illuminant Lamp.

oxide being used as a filter. Most protoplasmic substances which are colourless in ordinary light show marked absorption to ultra-violet rays, and this is made use of in miscroscopy to obtain contrasts.

If a paint made of Chinese white (zinc oxide), either used alone or, better, mixed with a little lamp-black to form a light grey, is applied to form a flat and not a glossy surface, it will absorb all ultra-violet radiation, not allowing any to be reflected. This is of importance when the wall-covering of a treatment-room is being considered.

Reflection of Ultra-Violet Radiation.—" Ultra-violet

radiation often undergoes considerable absorption by reflection. Many substances reflect the near ultra-violet fairly well, but the middle and extreme ultra-violet are generally absorbed to a considerable degree. Much of the ultra-violet energy is absorbed by some substances in excitation of fluorescence" (Luckiesh).

Snow reflects ultra-violet rays extremely well, as it does visible light, and this accounts for the development of snow-blindness under certain conditions, ultra-violet rays down to 2950 Å being reflected, and commonly from 80 to 90 per cent. Luckily the limit of the transparency of the cornea to short wave-lengths is about the same as the short-wave limit of the solar spectrum. "Partial eclipse blindness" falls into the same category as snow-blindness, being due to the short wave-lengths present. In arc welding and allied trades it is now customary to wear special darkened glasses to protect the eyes from the ultra-violet rays generated and to prevent the occurrence of conjunctivitis.

An ordinary mirror which reflects excellently in the visible area falls to about 4 per cent. at 3160 Å. It rises, however, to 34·1 per cent. at 2510 Å. Silicon is the most efficient reflector, as it reflects 75 per cent. of the rays and an average of 60 per cent. for the whole range from 3800 Å to 1800 Å. Copper and gold reach their minimum between 3500 Å and 4000 Å, but reflect 38·8 per cent. at 2810 Å. Nickel reflects 40 per cent., whereas silver reflects only 6 per cent. of the incident rays.

Magnalium—an alloy consisting of 69 parts of aluminium and 31 parts of magnesium—reflects 80

per cent. of visible light, dropping to 67 per cent. for wave-lengths of 2500 Å; and it is stated that this reflective power does not deteriorate with age. But polished nickel is generally considered to be the most practical reflecting medium for ultra-violet rays.

FIG. 98.—The "Hanovia" Analytic Quartz Lamp.

Ultra-violet rays were successfully used for signalling in the late war, all the visible light being cut off from the source of radiation by an arrangement of special glasses. Small barium platinocyanide screens, which fluoresced in the presence of ultra-violet radiation, were used to receive the signals. Generally these screens were attached to telescopes and field-glasses.

Fluorescence.—A large number of substances are fluorescent, but the phenomenon is not ordinarily noticeable, because the brightness of the source of

light overshadows the much fainter fluorescence. If, however, nickel oxide glass is used with the mercury

FIG. 99.—A Photograph taken in a room, in Total Darkness, by means of Invisible Ultra-Violet Rays from a "K.B.B." Mercury Vapour Lamp filtered through a Chance Ultra-Violet Filter. It demonstrates the great Actinic Power that these invisible rays have on a photographic plate.

vapour lamp, practically all the visible rays are cut off and only the invisible ultra-violet rays allowed to

pass. The sun appears as an orange-red disc when looked at through this filter, while only the red metal filament of the gas-filled lamp can be seen.

Many substances show very beautiful fluorescence under the influence of these rays, particularly if the room is in darkness. Sodium salicylate exhibits a strong violet fluorescence, quinine sulphate a light blue, the dye rhodamine a bright orange-yellow, and fluorescin a yellow.

The finger-nails fluoresce much more markedly than the fingers themselves.

With this filter it is an easy matter to distinguish natural Oriental pearls from Japanese cultivated ones. Under the rays, we have noticed, the natural pearls have a bluish fluorescence and the Japanese a yellowish green. Artificial pearls appear quite dead and show no fluorescence at all.

Fresh eggs show a reddish fluorescence, stale eggs a dirty violet.

The rays can also be used for examining old parchments which, owing to their cost in olden days, were often written over several times. With the ultra-violet rays the old erased characters become apparent, and they are often of greater archæological interest than the superimposed visible writing.

Sometimes spectacular effects on the stage are achieved by passing ultra-violet rays through oxide-of-nickel glass, thus causing fluorescent substances to become luminous.

CHAPTER VIII

BIOLOGICAL EFFECTS OF ULTRA-VIOLET RADIATION

Absorption by Protoplasm—Effect on *Cyclops quadricornis*—Effect on Growing Seedlings—Sensitization of Cells to Light—Effect of Rays on the Skin—Erythema—Pigmentation—Effects on Bacteria—On Cardio-Vascular System—On Blood—On Metabolism—Calcium Metabolism—On Endocrine Glands—On the Eye—On the Alimentary System—On the Nervous System

THE physiological effect of light is probably mostly due to the photochemical reactions which result when light is absorbed. Most of the constituents of living cells are colourless, as they do not absorb visible rays, but the great majority of them absorb ultra-violet rays strongly, so that ultra-violet radiation has a marked effect on living cells, as could be expected from Grotthus' law. This fact is made use of in taking microphotographs of living tissues.

It has been found that the different constituents of protoplasm commence absorbing light markedly in the region of 3000 Å. The whole protoplasm of minute organisms is affected when they are exposed to ultra-violet radiation, and the laws of simple photochemical reaction govern the change. We ourselves repeated some experiments showing the effect of ultra-violet radiation on the small pond crustacean *Cyclops quadricornis*. They were exposed in a Petri dish containing

tap water at a uniform distance of ten inches from a "Hewittic" burner. In one series of experiments we placed two cyclops in Petri dishes. These were exposed to ultra-violet rays until all movement had ceased. At first mobility was greatly increased, the cyclops going round in small circles at a very rapid rate, but movement gradually slowed down until it finally ceased. This time was noted with a stop-watch :

Uncovered Petri dish	All movement of cyclops ceased in	1 min. 15 sec. 1 min. 40 sec.
Petri dish covered with thin celluloid	" " "	3 min. 50 sec. 3 min. 50 sec.
Petri dish covered with 15 oz. glass	" " "	5 min. 30 sec. 6 min. 30 sec.
Petri dish covered with 21 oz. glass	" " "	5 min. 30 sec. 5 min. 30 sec.
Petri dish covered with 26 oz. glass	" " "	8 min. 10 sec. 8 min. 20 sec.

—showing that glass cuts off most of the abiotic radiations. Next, pairs of cyclops were placed in watery solutions of two fluorescent dyes—viz. auranine O and fluorescin—for twelve hours, then removed and placed in tap water in Petri dishes as before, with the following results :—

Cyclops which had been in auranine O solution	All movement ceased in	6 min. 45 sec. 8 min. 30 sec.
Cyclops which had been in fluorescin solution	" " "	8 min. 38 sec. 8 min. 30 sec.
Control with untreated cyclops in Petri dish	" " "	3 min. 0 sec. 3 min. 45 sec.
Control covered with 15 oz. glass	" " "	8 min. 15 sec. 8 min. 45 sec.

These experiments show that previous immersion of the cyclops in a fluorescent solution has the effect of protecting it from subsequent exposure to ultra-violet rays, the fluorescent matter present converting the ultra-violet rays into visible rays, which are not generally harmful to protoplasm. If, however, the size of the organism is greater, the effect is more a surface one, owing to the small penetrative power that the ultra-violet rays possess, but there is a partial diffusion of the reaction throughout the organism. The exact effect of ultra-violet radiation on protoplasm is unknown, but definite alteration in its chemical composition occurs.

Experiments to show the Effect of Ultra-Violet Radiation on Seedlings.—I. Cress seeds were sown in four small jars covered with muslin, kept moist with water and at a fairly warm temperature (about 60° F. average).

No. 1 was grown in total darkness.

No. 2 was grown in darkness, but exposed daily to radiation from a mercury vapour lamp at a distance of 24 in. for thirty minutes.

No. 3 was grown in darkness, but was exposed in the same way as No. 2, for sixty minutes daily.

No. 4 was grown in daylight.

Results:

No. 1 showed typical etiolated growth. The seedlings were very tall and delicate and showed no sign of chlorophyll formation.

No. 2.—The seedlings were very short and shrivelled-looking. Some of the seeds did not germinate. There was a slight sign of chlorophyll formation.

No. 3.—Several of the seeds did not germinate. Growth was very short and the plants looked burnt-up. Chlorophyll was present in the small wizened leaflets.

No. 4 showed normal sturdy growth, with abundant chlorophyll. This shows that unfiltered radiation from a mercury vapour lamp is inimical to plant growth, but aids chlorophyll formation.

II. Mustard seeds were sown as above in seven jars covered with muslin and provided with warmth and moisture.

No. 5 was grown in total darkness.

No. 6 exposed for five minutes daily to ultra-violet radiation, and then grown in darkness.

No. 7 exposed ten minutes daily, and then grown in darkness.

No. 8 exposed fifteen minutes daily, and then grown in darkness.

No. 9 exposed twenty minutes daily, and then grown in darkness.

No. 10 grown in daylight.

No. 11 grown in daylight, and exposed for five minutes daily to ultra-violet radiations from mercury vapour lamp.

Results :

No. 5 seedlings showed etiolation—no chlorophyll formation.

No. 6.—Inhibition of growth—slight chlorophyll formation.

No. 7.—Greater inhibition of growth—some chlorophyll formation.

No. 8.—Greater inhibition of growth—some chlorophyll formation.

No. 9.—Same wizened appearance of seedlings as before—some chlorophyll present.

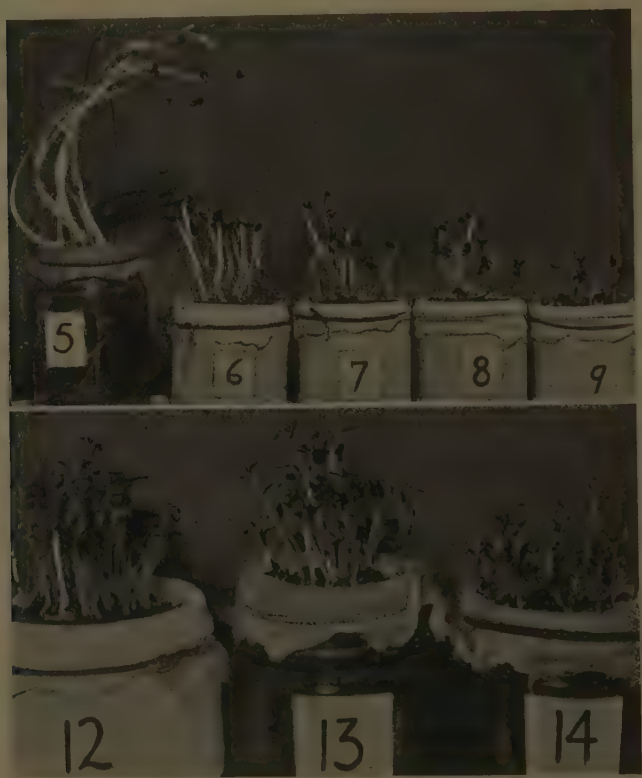


FIG. 100.—Illustrating the Effect of Ultra-Violet Rays on Seedlings.

Jars 5-9: Effect on Mustard Seedlings. Jar 12: Cress Seedlings grown in Daylight.. Jar 13: Also grown in Daylight, but covered by glass and exposed to U.V.R. for thirty minutes daily. Jar 14: Again grown in Daylight, but exposed to U.V.R. for thirty minutes daily.

No. 10.—Normal healthy growth—normal amount of chlorophyll present.

No. 11.—Same inhibition of growth as in seedlings 6, 7, 8 and 9 grown in darkness—normal amount of chlorophyll present.

FIG. 101.—Showing the Effect of Ultra-Violet Radiation on Mustard Seedlings.

It is seen that even short exposure to ultra-violet radiation given off by an unscreened mercury vapour lamp is detrimental to plant growth, while equally

small doses aid chlorophyll formation. This effect on plant life is different from that which is found on exposure of seedlings to radium emanations, for, although large doses of these inhibit growth, small doses stimulate it.

It is possible, by the use of eosin, chlorophyll, some derivatives of hæmoglobin (hæmatoporphyrin), and certain analine dyes, to sensitize living cells and to cause, by the action of visible light, abnormal conditions such as are otherwise produced only by means of ultra-violet radiation. For example, if a mouse is sensitized by the injection of eosin, no change takes place in darkness, but the animal dies within a few hours when exposed to daylight.

Perhaps the most noticeable biological effect of ultra-violet radiation is the effect it has on the skin. At the time of radiation nothing is felt by the patient excepting perhaps a faint sensation of warmth due to the incandescence of the quartz. No reddening is noticed at the time, but after a latent period, which varies with almost every patient, but is generally from four to eight hours after exposure, a feeling of heat is experienced in the part. According to the period of irradiation this feeling may increase and lead to great irritation, and even to pain. The part becomes red, hot and slightly swollen, and exhibits all the signs of mild inflammation, varying in severity according to the dose and sensitiveness of the patient. This erythema gradually fades and is followed by desquamation. We have noticed that if a second exposure is made on the same part within ten days of the first this erythema is not repeated, but, if a larger area is

exposed, the part which is freshly irradiated undergoes similar changes to the first; also when a patient is irradiated with the arms and neck bare, and the shirt front open, and at the next exposure the whole chest exposed, the neck and V appear pale when contrasted with the intense erythema of the surrounding skin. Desquamation occurs about four or five days after exposure, though the hyperæmia may last for several weeks, or only for two or three days. After continued irradiation, pigmentation of the skin results.

Probably owing to the vasodilatation which accompanies the erythema, or to sympathetic paresis, there is almost invariably a fall in the arterial blood pressure. In one case, in particular, we found a fall of 20 mm. of mercury after five minutes' irradiation by the mercury vapour lamp at thirty-six inches distance, though this fall occurred before erythema appeared.

Rollier says, "Sunlight is the best masseur," and it will be found that the texture of the skin rapidly improves under irradiation. The condition of the underlying muscles also improves, and flabby wasted limbs soon become strong and firm. Tubercular children whose limbs are being treated by complete immobilization do not get muscle-wasting and loss of tone when exposed to sunlight. Sunlight undoubtedly stimulates symmetrical muscular development.

The whole metabolism of the body is quickened, and the general health and vitality benefited.

Ultra-violet rays assist in the formation of antibodies in the blood, and so the immunizing power of the body is raised.

The general action of the rays is proved by the

effects which they have on lesions far distant from the part irradiated.

An indirect effect which can be claimed for ultra-violet radiation is that it counteracts the diarrhœa and bronchitis which are so often found in rickets. This we have noticed in our own patients whom we are treating for rickets. Another important action of ultra-violet rays is their analgesic effect. It is thought that the rays exert some biologic action on the irradiated interepithelial nerve fibrils. We have noticed this effect chiefly in cases of *Herpes zoster*, when the acute pain is relieved even after the first exposure.

Deeper visceral pain is also often allayed. This may be due to the erythema and consequent lessening of internal congestion, or to the effect on the peripheral area, according to the view that there is a reflex relationship existing between many superficial areas and internal organs.

The Effect of Ultra-Violet Rays on the Skin.—The absorption by the skin of ultra-violet rays, especially the rays of very short wave-length, is very great, all rays shorter than 3000 Å being absorbed by a layer of epidermis 0·1 mm. in thickness. The shorter the wave-length the thinner the layer which will completely absorb it: 2·5 mm. of skin are opaque to indigo and violet rays (4358 Å). Long wave-lengths are absorbed less. This is easily seen by noting the sensation of red which is experienced when the eyes are closed and a source of light placed in front of them, or when the facial sinuses are illuminated. We have noticed that if the eyes are closed when standing close to the quartz mercury vapour burner a sensation of green

is apparent, proving that red rays are absent in the mercury vapour radiation, and also that the green rays are capable of penetrating the eyelids.

Blood serum absorbs all rays below 3000 Å, and normal blood absorbs all rays with wave-lengths less

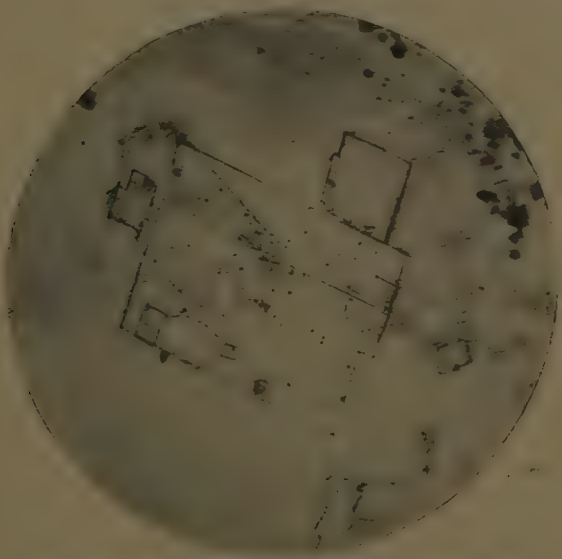


FIG. 102.—Specimen of Cholesterol crystallized from Solution in Alcohol. (Photograph by Mr Spencer Breslin.)

than 4500 Å, and also has two absorption bands—one at 5400 Å, and the second at 5750 Å.

As a result of the absorption of the ultra-violet rays by the skin certain changes take place.

It is thought that the rays convert the cholesterol in the skin into vitamin D, which stimulates calcium and phosphorus absorption.

Pacini mentions that there is at first a period of

vasodilatation, which is followed by vasoconstriction if irradiation is continued. This he proves by eliciting the "adrenal reflex" by stroking the skin, when it will immediately blanch and then appear red. If this is repeated when the part is being irradiated with the quartz mercury vapour lamp, at first one finds that the reaction time between the initial blanching (vasoconstriction) and ultimate reddening is markedly lessened; this is the period of vasodilatation. If the exposure is continued the reddening disappears, and is again succeeded by blanching (vasoconstriction). Therefore short exposures to the rays cause vasodilatation, and longer exposures vasoconstriction. A healthy non-pigmented skin adopts the appearance of "goose flesh" when exposed to cold; this rapidly disappears under the ultra-violet rays.

Erythema.—Erythema is undoubtedly one of the most important phenomena occurring in actinotherapy. It has been found that erythema causes an immediate rise in the amount of calcium in the blood, and that this decreases as the erythema fades.

Actinic erythema must be clearly distinguished from the erythema caused by infra-red rays which appears actually during irradiation and soon disappears afterwards, whereas actinic erythema appears only after a latent period of from four to twelve hours. This latent period is very variable.

The erythema varies in severity, according to the length of exposure and sensitiveness of the patient, from a faint reddening to necrosis of the epidermis with the formation of blisters containing serous fluid. Fair people react more strongly than dark, and the

"red" type is more sensitive than either. Children are particularly sensitive, and young people more so than old. We have also found that normal skin is more sensitive to irradiation than morbid skin, and also that parts which are generally exposed to the light—hands, arms and face—react much less than the parts covered by clothing.

The time that the erythema persists also depends upon its severity and the reactivity of the patient, and varies between two days and several weeks.

Erythema is sometimes preceded by an abnormal sensitiveness of the skin; the colour of the erythema disappears on pressure.

Erythema is accentuated when ultra-violet rays are applied conjointly with luminous and infra-red rays. Rays between 3130 and 2530 Å can cause erythema, but the maximum effect is produced by rays of 2970 Å, which provoke one-third of the total erythema.

Chemical changes occur in the stratum corneum, where the ultra-violet rays of short wave-length are absorbed, but the maximum vital response takes place in the cells of the basal layer of the *Rete mucosum*. This important layer of cells has for its function the reproduction of destroyed skin, keratinization, and the formation of pigment. The capillaries in the dermis are influenced by the absorption of substances formed in the irradiated epithelial cells.

The phenomenon is probably partly photochemical and partly photoelectric, due to the actual penetration of electrons.

Microscopic examination of the skin reveals serous

swelling in the deeper layers of the epidermis, the cell nuclei of the granular and malpighian layers being specially affected. Vesicles form and there is a migration of leucocytes into these two layers.

The diameter of the capillaries increases from two to four times their normal size. The blood stream slows down till it comes to a standstill in the affected area.

Twenty-four hours later there is active diapedesis from the non-thrombosed vessels, with marked œdema, and the reaction is at its height about thirty hours after exposure.

When the exudation is sufficiently great to break continuity between the stratum corneum and the stratum granulosum, blisters occur. The thrombi in the superficial vessels are removed by phagocytes. Some days later, if the exposure has been sufficiently powerful to cause necrosis of the epidermal cells, desquamation results.

Fauré-Fermiet, experimenting on the eggs of a certain ascaris, found that fragmentation of the chromosomes occurred. This probably takes place in the human epidermal cells on irradiation, and the subsequent erythema which occurs after several hours may be due to some substance formed from the broken-up chromatin.

Pigmentation.—After repeated doses this erythema is followed by pigmentation, which is due to the deposition of the pigment melanin as granules round the nuclei of the basal cells of the epidermis. They thus form a screen round the nuclei and protect them form an overdose of ultra-violet rays, and when

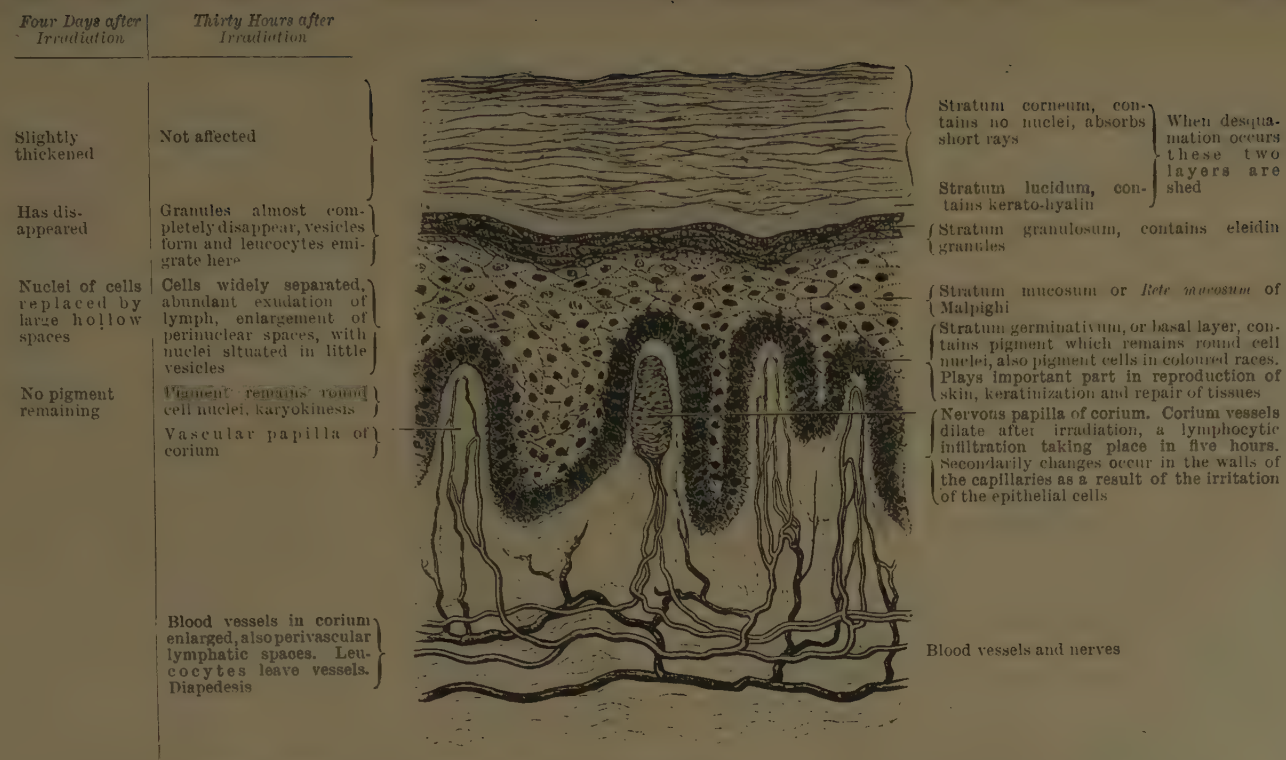


FIG. 103.—Vertical Section of the Epidermis and Papillæ of Corium. After Irradiation of the Skin the primary changes occur in the Epidermal Cells, which absorb the Ultra-Violet Rays, the Stratum Germinativum or Basal Layer being especially affected. The cells of this layer produce horny substance and pigment, and are also constantly forming new cells. They also secrete a substance which is absorbed by the blood vessels of the corium, and thus circulates throughout the body.

pigmentation has once taken place there is much less danger of excessive actinic erythema. In therapeutics the appearance of pigmentation necessitates the administration of longer exposures.

The rays which are most potent in producing pigmentation are those between 2900 Å and 3300 Å, which are the shortest wave-lengths of the solar spectrum. Waves shorter than 3300 Å are absorbed by glass, and it is known that pigmentation does not take place if sunlight first passes through glass, so the longer waves do not cause this effect. Again, rays shorter than 2900 Å produce a strong erythema which is not followed by any marked pigmentation.

The screen formed by the pigmentation is thought to convert light into heat. Its use as a screen is evident if some melanin, obtained from the eye of an ox, is mixed with water, placed in a quartz tube, and held in the palms of the hands, while the sun's rays are focused on it by means of a burning-glass. The skin underneath the tube is unharmed, but the water in the tube is evaporated by the pigment absorbing the rays and converting them into heat. In the same way the deeper structures of the skin are protected and profuse sweating is promoted.

Pigmentation also ensures the maximum amount of absorption of ultra-violet radiations, and therefore an increased therapeutic reaction. Rollier observed close parallelism between the amount of pigmentation and the beneficial therapeutic results and he considers that the possible influence of pigment is in transforming rays of short wave-length into longer and more penetrating ones. The theory was based on the fact

that in some places where the amount of sunlight, and hence pigmentation, is small better results were obtained when fluorescent substances were painted on or injected under the skin.

Rollier is inclined to think that if pigment is so important in phototherapy, then it is due to its influence that this fall in potential in photochemical reactions takes place, but under Wood's monochromatic light, which produces fluorescence in all substances possessing that property, freckles and pigmented areas are found to be entirely non-fluorescent. Reyn, however, disagrees with Rollier and says non-pigmenters often show excellent therapeutic results.

Gordon Pugh, at Carshalton, has investigated 232 cases of tuberculosis of the spine, hip and knee joints, and carefully noted the degree of pigmentation in each case. Three and a half years later the mortality among the very good pigmenters was found to have been 16 per cent. ; 15 per cent. among the good pigmenters ; 10 per cent. among the slight pigmenters ; and only 9 per cent. among the non-pigmenters.

Melanin itself is supposed to be the end product of oxidation of tyrosin, probably through the agency of an oxidizing ferment such as tyrosinase.

Bloch proved the presence of an enzyme in the production of melanin, which he termed " dopa oxydase." He made use of dioxyphenylalanin, which he brought into contact with skin. A brown coloration resulted, which was granular and appeared in the basal cells of the epidermis. This reaction did not take place in an albino skin, and was activated by all agents causing pigmentation, especially light.

Variations in the colour of the pigmentation obtained from different sources of radiation have been noticed, the carbon arc producing a reddish brown hue and the mercury vapour lamp a more greyish coloration.

Sequeira has found that he is able to produce pigmentation more rapidly with the carbon arc than with the mercury vapour lamp.

Pigmentation is also associated with the resistance of the skin to infection. It has been found that in the case of specific infections the rash did not appear on the pigmented parts of the body, but was present on any white skin which had been kept covered. Dr Leuba noticed in the Swiss army that men who had been used to working in the fields, stripped to the waist, and had become pigmented, would not respond to vaccination until the skin was actually cut through instead of the usual scarification.

Skin infections such as acne and boils are almost unknown among black tribes. Artificial ultra-violet rays produce the same effect, making it practically impossible for skin infection to exist or occur.

The temperature of the skin, underlying tissues and the blood are raised, owing to the absorption of the rays, and the conversion of the radiant energy of lower wave-length into heat. This results in stimulation of the sweat glands, either locally over the part irradiated, or generally, owing to the raising of the general temperature by the circulation of the warmed blood. The pigmented skin is efficient in protecting patients against changes in temperature and exposure to dampness.

Pigmentation may persist for a considerable time. Two years ago one of the authors exposed several small areas on both forearms to ultra-violet radiation for the purpose of preparing an illustration showing the use of the test dosage armlet. Several of these areas can still be clearly distinguished.

Effects on Bacteria.—In 1877 Downes and Blunt proved the bactericidal action of light. Two series of culture tubes were submitted to irradiation, one of the tubes was surrounded by lead-foil, which would prevent the action of light, but not that of heat. The other tubes were left uncovered, and it was found that only in the former did the organisms grow. The media in which the bacteria were killed were again inoculated with organisms which developed normally, proving that the light acted on the organisms themselves and not on the media, and that the heat had no bactericidal effect.

In 1890 Robert Koch showed that tubercle bacilli were killed by light. Sputum bacilli spread in a thin film on glass slides and exposed to direct sunlight are killed in ten minutes.

In 1917 Browning and Russ threw the spectrum of a tungsten arc light through a quartz spectrograph on to a gelatin plate inoculated with micro-organisms. Sharply defined vertical areas resulted, some showing growth, others showing none. The region shown to be most actively bactericidal lay between the rays of 2960 Å and 2100 Å. Wave-lengths slightly longer than 2960 Å were lethal after much longer exposures, or at a higher temperature. The sharp lines of demarcation suggested selective absorption, and this

was proved by examining absorption spectra of suspensions of organisms which were used in the former experiments.

The absorption of ultra-violet rays by bacteria is principally due to the large amount of tyrosin and phenylalanin which they contain, and epithelial cells may often be stimulated by rays which are markedly bactericidal.

The region of the rays absorbed by the bacterial emulsion corresponded almost exactly to the portion of the spectrum of most marked bactericidal power. Browning and Russ divided the ultra-violet region as follows :—

Group 1 : region 3800 Å to 2960 Å—the region where there is no marked bactericidal effect, but which has most power of penetration.

Group 2 : region 2960 Å to 2100 Å—the region showing marked bactericidal effect, but not capable of penetrating one-tenth mm. thickness of skin.

Opinions as to the action of the rays of longer wavelengths are diverse. Some consider that they favour the growth of the bacilli. Mackie and Van der Lingen exposed cultures of organisms to the different colours of the spectrum by means of coloured glasses. The temperature was kept constant as the cultures were placed in incubators and the lamps outside. The intensity of light was kept constant by means of actinometers. They were exposed from forty-two to fifty-four hours. Inhibition of growth was most marked under the red and orange rays. Under white light there was very little change. All scientists, however, are united in recognizing the powerful germicidal

action of the shorter ultra-violet rays. Some thought that this was due to the formation of certain substances in the medium which killed the organisms—namely, ozone and hydrogen peroxide—but the short length of time necessary (fifteen to sixty seconds) for the lethal effect proved this theory to be incorrect, as it takes a much longer time for even the slightest trace of these substances to be formed. Also if the medium is inoculated subsequent to irradiation there is no effect on the organisms.

Water can be sterilized by ultra-violet radiation if it is passed through an apparatus where it must come into contact on three occasions with a quartz plate which separates it from a mercury vapour lamp.

Ultra-violet radiation destroys the secretions and toxins of organisms, but only after a longer period than is necessary to kill the organisms themselves. The resistance of bacteria to ultra-violet radiation does not vary in the same way as their resistance to antiseptics and to heat.

Young cultures are more sensitive than old ones. Spores are often twenty times more resistant to certain chemicals than bacteria are, but this is not the case with their resistance to ultra-violet radiation, where the figure is only 1·5 to 5 times. The abiotic effect is independent of temperature. It can take place just as easily in clearly frozen ice as it can in water.

Ultra-violet rays are absorbed by the protoplasm of the organism, and in a culture, or on the surface of a wound, one bacterium will protect a second lying under it ; so in a lesion such as lupus the whole beneficial therapeutic effect cannot be considered to

be due to the bactericidal effect of the rays, but is also due to an increased bactericidal property of the blood itself, increased lymphocytosis in the part, and stimulation of cicatrization.

The destructive effect on bacteria is apparently due to coagulation, one view being that ultra-violet radiation kills living cells and tissues by affecting their protoplasm in such a way that it is made possible for certain salts to combine with the protein of the protoplasm and form insoluble compounds.

The colloids of the cell, particularly of the nucleus, are modified.

Another theory is that the cause of death of the bacteria is the heat coagulation which follows sensitization by ultra-violet radiation.

Wishing to prove the bactericidal action of ultra-violet radiation for ourselves, we exposed Petri dishes containing agar sown with fresh cultures of staphylococcus aureus and bacillus coli to the radiations from a mercury vapour lamp at a distance of ten inches. We found that all the organisms were killed after five seconds' exposure. We repeated the experiment, but placed screens of various materials between the lamp and the organisms, and found that no inhibition of growth took place when the rays passed through glass, only very slight inhibition when they passed through celluloid, and marked inhibition with gelatin. This shows that glass cuts off rays having wave-lengths shorter than 2960 Å, while celluloid allows some bactericidal rays to pass through, whereas gelatin is even more permeable to these rays.

The agar plates on which the growth of bacteria

had been killed were again inoculated for twenty-four hours at 37° C., and normal growth was found, showing that the rays act on the bacteria themselves, and not on the medium on which they are grown.

Cardio-Vascular Effects.—When the body is exposed to ultra-violet radiation dilatation of the surface capillaries results in disengorgement of internal viscera and vessels. The blood pressure in cases of hyperpiesis is thus reduced and the patients greatly relieved.

Several eminent phototherapists have proved this phenomenon, and we ourselves have had very satisfactory results in cases of hyperpiesis in practice, especially in cases where the systolic blood pressure exceeded 200 mm. of mercury.

The general health of the patient improves, headache is relieved, and the "weighted" feeling of the limbs disappears. In cases of heart lesions the dilatation of cutaneous vessels and lowering of blood pressure lessens the work of the heart.

Chilblains have been successfully treated by actinotherapy; so also have cases of Raynaud's disease.

Effects of Ultra-Violet Radiations on the Blood.—Normal blood absorbs all rays with wave-lengths less than 4500 Å, and has two absorption bands, one at 5400 Å and the other at 5750 Å. How the rays of energy are stored and carried is as yet unknown. It is thought probable that some photochemical product is formed at the surface and conveyed to the internal organs by the blood stream.

It is generally agreed that exposure to ultra-violet rays increases the number of red blood corpuscles.

Rollier finds that an increase in the amount of hæmoglobin and the number of red corpuscles is constant in patients undergoing heliotherapy, but altitude may play a part in these cases.

In a series of blood estimations which were made in the case of a large number of soldiers, first in a temperate climate and then after their transfer to the tropics, it was found that the red blood corpuscles and lymphocytes were considerably increased in number and the polymorphs decreased, and the blood pressure was also lowered.

It seems certain that ultra-violet rays stimulate the hæmopoietic system.

We ourselves found an increase in the number of erythrocytes—from 4,300,000 to 5,725,000 occurred in one case in three weeks. The hæmoglobin increased from 70 to 90 per cent. in the same length of time.

Sunlight, ultra-violet rays, and heat all produce an increase in the lymphocyte count.

The lymphocytosis caused by ultra-violet radiations has been found to be almost entirely due to rays shorter than 3300 Å. Rays longer than 3300 Å cause leucopenia. Bunting and Huston have shown that more lymphocytes can enter the blood stream from the thoracic duct during twenty-four hours than are present in the blood stream at any time. The excess of cells migrates from the blood vessels into the mucous membranes, chiefly of the gastro-intestinal tract. If small animals are killed after irradiation by the mercury vapour lamp, the lungs, liver and spleen are found to be greatly engorged with blood, especially the spleen. Thus it is supposed by some that the

increase in white cells is due to stimulation of the lymphocytic organs.

This engorgement of the viscera, of course, cannot be proved in human beings, and an opposite action is thought to take place owing to the cutaneous erythema and lowered arterial blood pressure.

Some observers have noticed a slight increase in eosinophilic leucocytes after irradiation. We ourselves found on making differential counts in one case that these cells increased from $3\frac{5}{9}$ to 6 per cent. in a fortnight, this being a relative increase of 69 per cent. The number of blood platelets in the blood is also increased. If an animal is kept in darkness and fed on a diet deficient in fat soluble A vitamin the number of blood platelets is reduced, but the platelets are rapidly increased to normal after irradiation with the quartz mercury vapour lamp. Cramer and Drew consider that blood platelets are part of the defensive mechanism against infection by bacteria.

Sonne found a rise in the antigenic property of the blood after irradiation, by testing its effect on typhoid agglutinins, and by its increased resistance to diphtheria toxin.

Red corpuscles in the blood are protected from hæmolysis by the absorption of the ultra-violet rays by the serum. This protective action is supposed to be due to the absorptive power of certain amino-acids contained in the serum—namely, tryptophan and tyrosin. Red corpuscles suspended in saline are readily hæmolysed by ultra-violet rays, probably by the absorption of the rays in a similar way by the tyrosin and phenylalanin, which are also present in the protein

of living cells, with the result that the chemical composition of the cells is changed and cellular death occurs.

Ultra-violet radiation increases the amount of calcium, phosphorus and iron in the blood. It augments the iodine content of the thyroid gland, and it raises the temperature of the blood.

Experiments on Human Blood.—Owing to the kindness of Professor Burns (Professor of Physiology, Durham University) we were able to carry out some experiments on the effect of irradiation with ultra-violet rays on the human body. The lamp used was of the "K.B.B." pattern, and irradiation was carried out at thirty inches from the lamp in a dark room. At first short doses were given, and these were gradually increased to thirty minutes' exposure of the back and front of the whole body daily. The irradiation was continued for twenty-three days (three Sundays excepted), and frequent notes were made of the pulse, systolic blood pressure, number of red and white cells per cubic millimetre, and also of the percentage of the various types of leucocytes. The following results were obtained.

The pulse rate remained practically unchanged. The systolic blood pressure tended to drop slightly, the hæmoglobin percentage rose proportionately from 70 to 90 per cent., and the red blood corpuscles also increased from 4,300,000 to 5,725,000. The total number of white cells varied a little, the first and last figures being 10,500 and 11,926 per cubic millimetre respectively. By far the most interesting changes were those which occurred in the relative numbers of

the white blood corpuscles—*i.e.* the differential counts. The initial figures were: polymorphs, $70\frac{4}{9}$ per cent.; large mononuclears, $5\frac{7}{9}$ per cent.; small mononuclears, $20\frac{2}{9}$ per cent.; eosinophils, $3\frac{5}{9}$ per cent. The final figures were: polymorphs, $56\frac{2}{7}$ per cent.; large mononuclears, $6\frac{4}{7}$ per cent.; small mononuclears, $31\frac{1}{9}$ per cent.; eosinophils, 6 per cent. The polymorphs decreased progressively, though the greatest drop was early. The total fall was 20 per cent. The large and small mononuclears, or lymphocytes, on the other hand, showed a large increase (most marked in the small lymphocytes) of 45 per cent., and the eosinophils increased 69 per cent.

The effect of ultra-violet radiation, therefore, on the blood is to cause a slight increase in the red and white corpuscles, and in hæmoglobin; to cause a diminution in the polymorphonuclear leucocytes, an increase in the lymphocytes, and, most markedly of all, in the eosinophilic cells.

It is also known experimentally that the immunizing and bactericidal properties of the blood are increased, but the connexion between these and the changes in the differential white count is not obvious, as it was always thought that the polymorphs had the greatest bactericidal effect, and yet they are actually and relatively decreased.

The following authorities give the average number of white blood corpuscles per cubic millimetre as follows:

Howell	5000 to 7,000
Gray's *Anatomy* . .	7000 to 12,000
Schafer	8000 to 10,000
Halliburton . . .	8000 to 10,000

And the percentage of different white cells as follows :

Polymorphs . .	60 to 70 per cent.
Eosinophils . .	1 to 4 ,,
Small Lymphocytes .	20 to 25 ,,
Large Lymphocytes .	1 ,,
Mast Cells . . .	0·5 to 1 ,,

Clinically an increase of polymorphs is seen in inflammatory and allied cases ; of lymphocytes in whooping cough, rickets, and congenital syphilis ; and of eosinophils in certain parasitic diseases and in many skin conditions.

Effects on Metabolism.—The exact way in which ultra-violet radiation affects metabolism has not yet been explained, but exposure to it deeply influences carbohydrate, fat, protein and mineral metabolism.

Rothman found that ultra-violet radiation reduces pathological blood sugar ; glucose disappears from the urine. The rays appear to have a regulating effect on carbohydrate metabolism, but normal blood sugar is not affected.

Ultra-violet radiation increases the oxidation of fats.

The amount of carbon dioxide expired is increased, and there is an increase of growth in daylight as compared with darkness. The appetite improves. Inspirations are also deeper and slower.

The increased temperature of the blood probably influences the rate of metabolism, as biochemical reactions may be greatly accelerated by even slight rises in temperature. Ultra-violet radiation has the effect of activating vitamins in the body.

Rollier quotes an interesting case of a man aged

forty-five with benign *Diabetes mellitus* of several years' standing, glycosuria twenty grams per litre, easily controlled by dieting. Under heliotherapy the glycosuria practically disappeared on ordinary hotel diet. This was maintained during the whole period of treatment, but twenty-four hours without a sun bath brought the sugar back again.

Calcium Metabolism.—Another phenomenon following exposure to ultra-violet rays is the increase in the calcium content of the blood, and also the increase in the concentration of inorganic phosphorus; and it is probably due to these changes that actinic-ray therapy is so invaluable in the treatment of rickets. One cause of the beneficial effect is thought to be due to the decrease of micro-organisms in the intestine, thus allowing greater absorption of calcium and phosphorus. Two minutes' irradiation daily with the mercury vapour lamp at a distance of three feet prevents rats, kept in darkness, and fed on a ricket-producing diet, from developing rickets; and a similar dose of rays administered to a baby will double the amount of inorganic phosphorus in its blood in a fortnight.

Very interesting observations were made by Eleanor Mary Hume and Hannah Henderson Smith, of the Lister Institute. Rats were placed in glass jars and kept in darkness. They were irradiated for ten minutes daily by means of a quartz mercury vapour lamp through the tops of the jars with the lids removed, and controls kept in total darkness. After irradiation the rats were removed, and fresh animals placed in the jars, which were then placed in darkness. It was noticed that the animals which were irradiated grew

most quickly. The ones which were placed in the irradiated jars grew more quickly than the controls, but not so quickly as the animals which were themselves exposed.

At first it was thought that the air in the jars was affected, but it was later found that if the sawdust was removed from the jar no change took place. A deal board was then substituted for the sawdust, which was also irradiated ten minutes daily. The result was that the animals which were then placed in the jars on the deal boards grew slightly more quickly than the controls, but not so quickly as when irradiated sawdust was used. It must be concluded, therefore, that in some way sawdust is able to absorb the ultra-violet rays and later emit them.

It has been suggested that the reason why cod-liver oil is beneficial in rickets is that the cod-liver oil itself emits ultra-violet rays when oxidized.

Interesting experiments have been made recently by Ethel Marjorie Luce, in which cows were kept in dark byres and in sunlit fields, and the results of feeding animals on the respective milks were noticed. It was found that the growth of the animals was the same in each case, but the ones fed on the milk from cows kept in the open were less liable to rickets.

Calcium salts play an important part in many body processes. They have a tonic action on the heart and stimulate the peripheral circulation, and because of this are valuable in the treatment of chilblains, and erythematous rashes are relieved.

Calcium salts diminish the permeability of the lymph and blood vessels, and so lessen the possibility

of hæmoptysis and epistaxis; they also reduce the amount of secretions and ameliorate catarrhs; they stimulate the phagocytic action of the leucocytes and aid the absorption of exudates.

The sebaceous glands are stimulated.

Calcium salts reduce anaphylactic reactions. They improve the emotional tone, and nervous irritability is lessened.

Most of the endocrine glands influence calcium metabolism, and stimulation of the sympathetic system increases the cellular intake of calcium. Calcium and phosphorus are influenced chiefly by rays of 3022 Å to 2600 Å. Shorter wave-lengths are antagonistic to an increase of these salts, so that, in certain cases, irradiation should not be given with the patient a shorter distance than thirty-six inches from the lamp.

Endocrine Glands.—The suprarenal glands and the ovaries are specially affected by ultra-violet radiation, but the testicles and thymus are influenced too. Some recent experiments performed on rabbits showed that the weight of the parathyroid glands increased from 14·1 to 51·1 per cent. after irradiation.

Effects of Ultra-Violet Rays on the Eye.—Only visible rays—*i.e.* rays between 7600 Å and 3800 Å—are capable of penetrating the crystalline lens of the eye. These rays effect chemical changes in the visual cells, and the new substances formed act as stimulants. The theory originated from the discovery of the presence in the rods of a purplish pigment—rhodopsin or visual purple—which is bleached on exposure to light. The layer of pigment cells that lies in apposition to the

rods and cones acts as a medium for the regeneration of the visual purple.

Light from 3800 Å to 2950 Å is absorbed by the lens and causes it to fluoresce, which seems to act as a protection to the retina. If an eye in which the lens has been enucleated is irradiated, the retina loses chromatin in the ganglionic cells, and the development of vacuoles takes place in the protoplasm of these cells. The nuclei of the same cells are large and clearly defined, and have a vacuolar appearance, with a very distinct nucleolus. Every other part of the retina is affected to some extent. These changes may be noticed at once or may take several hours to develop. They are recovered from in a few days. Light of wave-length less than 2950 Å is absorbed by the cornea and conjunctiva, which results in conjunctivitis, cloudiness of the cornea with desquamation of the epithelium, together with iritis. There is an interval before this occurs, as there is in the skin reaction. These conditions disappear after a few days, but slight corneal trouble may persist for some time under certain conditions—*e.g.* with nutritive changes—or, in the presence of strong light, cataract may result.

Ultra-violet light reflected from snowfields may result in temporary injury known as snow-blindness. It is evident that the eyes must be very carefully protected from arc lamps, especially those rich in ultra-violet rays.

Effect on the Alimentary System.—Pacini has observed that gastric juice removed from the stomach during ultra-violet radiation shows a diminution in

the acid content, and he also holds that irradiation of the referred cutaneous sensitive areas will relieve the pain of most gastric lesions.

Reflex contraction of involuntary muscle occurs when it is irradiated, and this may be the reason why constipation is often relieved by irradiation, probably through the medium of the sympathetic system.

The erythema produced after exposure is sometimes useful in relieving congestion in cirrhosis of the liver. Microbic infection of the bowel is decreased, checking diarrhœa, and allowing substances to be more easily absorbed from the alimentary tract.

Effect on the Nervous System.—Ultra-violet radiation acts in the same way as natural sunlight in producing a feeling of mental exhilaration and cheerfulness, and a sense of well-being. Nervousness disappears and insomnia is benefited; fatigue is lessened.

Dr Wilcken has told us that "on Disco Island, Greenland, it is a well-known fact that people quarrel in the winter, the continued darkness 'getting on their nerves.' Disco Island is a Danish botanical and meteorological station, with a more or less constant population. Antarctic explorers visiting the Meteorological Institute in Buenos Aires have often told me how the winter's darkness affected their mental condition; and the expeditions sent out annually from the Argentine Meteorological Institute to Laurie Island, South Orkneys (about 61°5 latitude), frequently had trouble amongst the personnel owing to the depressing effect of the long winter."

The whole disposition of children often is altered by ultra-violet irradiation; there is an increased mental

alertness, and this has been conclusively proved by a recent series of intelligence tests.

The mental outlook of the patient is of supreme importance in many diseases.

Ultra-violet rays have a strong influence on the sympathetic system; they also have an analgesic effect, which is most readily seen when cases of herpes or neuralgia are irradiated.

Rothman considers that ultra-violet radiation temporarily paralyses the sympathetic nerve endings in the skin, which causes tonic depression of the whole sympathetic system.

This results in an inability of the suprarenal glands to convert tyrosin into adrenalin. Instead, this tyrosin is converted into melanin pigment in the skin.

In Addison's disease, which we know is due to disease of the suprarenal glands, there is also a hypotonicity of the sympathetic system, with excessive pigmentation and a low blood pressure.

Finsen's experiments, showing the stimulating effect of actinic rays on butterflies, have already been referred to in Chapter I.

When the vasomotor reflexes become sluggish owing to want of use, as when clothing is habitually worn, great susceptibility to variations in heat and cold exists. Exposure to ultra-violet rays improves the regulation of body temperature, which is such a very important function of the skin.

CHAPTER IX

TECHNIQUE

Arrangement of Surgery—Planning an Ultra-Violet Clinic—Choice of Lamps—Mercury Vapour Lamps—Position of Lamps — Air-cooled Mercury Vapour Lamp — Method of lighting Lamp — Contra-Indications to Treatment — Are Ultra-Violet Rays dangerous? — Symptoms which may follow Irradiation—Administration of Treatment—Raying Children—Position of Patient during general Treatment—Use of Ultra-Violet Rays in the Operating Theatre—Dosage—Cosine Law—Intervals between Applications of Treatment — Duration of Treatment — Local Treatment with Water-cooled Mercury Vapour Lamp — Lighting the "Kromayer" Lamp—Applicators and Compressors—Dosage with the "Kromayer" Lamp—The Carbon Arc Lamp—Trimming an Arc Lamp—Hissing—The Tungsten Arc Lamp—Combined Treatment—Remedies for Faults—Conjoint Internal Medication and Actinotherapy

MANY practitioners are greatly hampered in practising electrotherapeutics by not having sufficient space at their disposal, especially if only one room is available.

This makes it difficult for them to satisfactorily utilize these new methods of treatment. It is a great advantage for a practitioner to have several rooms for use in his practice: a waiting-room, dispensary, two consulting-rooms and a small dressing-room, the last-named having a door into one of the consulting-rooms if possible. Each room should be well lighted and ventilated, and have a satisfactory method of heating.

It is most satisfactory to maintain the room at a temperature of about 70° F. Electric fans may be used if the room gets too hot when mercury vapour lamps are installed, or the windows may be widely opened.

We find hot-water pipes and radiators fed from a small coke boiler most useful. They are clean and effective, and are not costly when once fitted. The room in which the ultra-violet apparatus is installed should be especially well heated, to avoid the possibility of patients feeling cold when they have to undress. Carpets or rugs are a more satisfactory floor-covering, for the same reason, than linoleum. Screens should be provided, so that patients can undress in privacy. The walls should be treated if possible with a light grey paint made from Chinese white and lamp-black, and applied with a matt surface. This paint has the property of not reflecting ultra-violet radiation.

In a clinic, conditions are quite different, and reflection from the walls may be desired, particularly if "Jesionek" lamps are being used. In this case the walls should be whitewashed. A small, portable couch is necessary in the room; we find a folding camp-bed very useful as a couch. It should have a pillow. A separate length of white linen huckaback towelling, 6 ft. by 2 ft. 3 in., should be provided for each patient who is having general treatment, and this should be used to cover the couch. The couch should, if possible, be placed near the radiator of the heating installation.

The resistances of some lamps are utilized to provide infra-red rays; they have reflectors and are

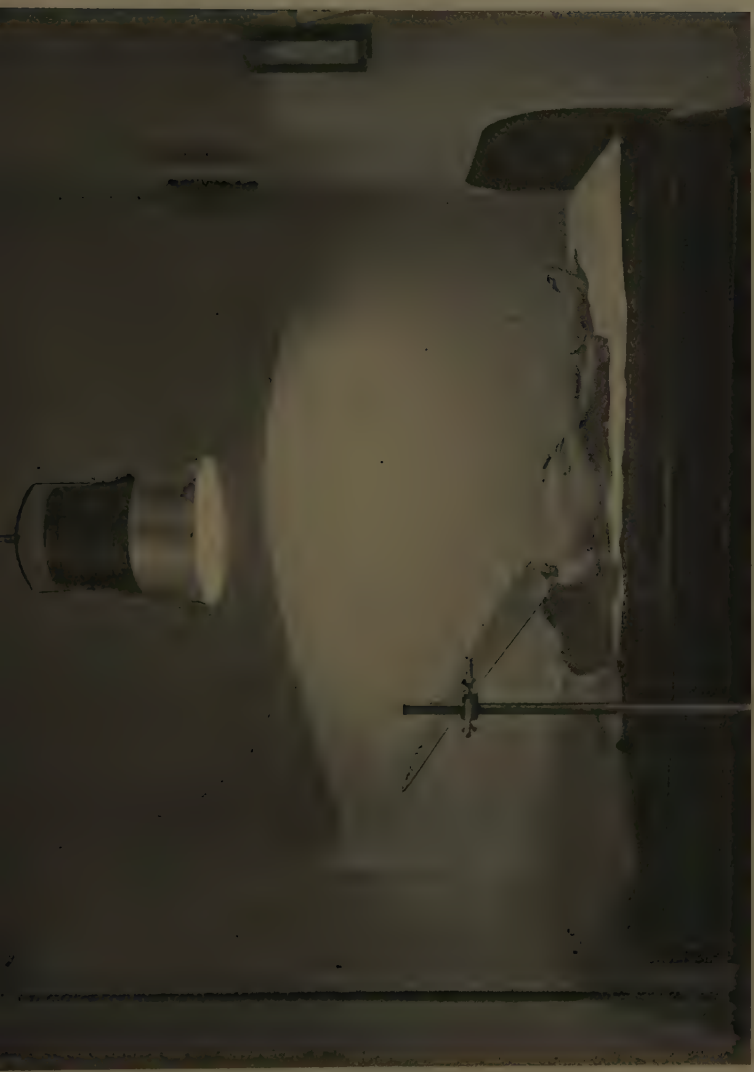


FIG. 104.—Our "Hewittic" Air-cooled Mercury Vapour Lamp with Magnetic Tilting Device, suspended from the ceiling by a Counterweighted Chain which passes over two Cog-Wheel Pulleys. This illustration shows how a small room 6 ft. by 11 ft. can be used conveniently for Ultra-Violet Treatment. A large roof window ensures efficient ventilation, and the room is heated by a hot-water radiator supplied by a small coke boiler.

mounted on stands. It is often convenient to place the patient between the ultra-violet and the infra-red lamps.

The windows of the treatment-rooms should be provided with blinds. Saidman suggests that the furniture should be painted black. There should be a mirror.

There are several accessories that we have found very useful. Black cotton gloves can often be worn with benefit by the actinotherapist when the "Kromayer" lamp is being used.

Non-inflammable celluloid combs are helpful when treating scalp lesions. An adjustable head-rest, which can be fixed to a chair, is invaluable in local treatment of the head.

Adhesive plaster, or "Antilux," can be used for protecting the area surrounding the lesion, and tie-clips are useful for fixing towels in position during local irradiation.

After carbon arc treatment a shower bath is generally necessary.

Some $\frac{1}{1000}$ solution of corrosive sublimate is necessary for sterilizing rock-crystal applicators.

It is very advantageous to have a record-card system, with individual cards for each patient.

The Planning of an Ultra-Violet Clinic.—The number of nursing staff available is of great importance. If there are several nurses, small treatment-rooms may be used, so that the different sexes can be treated during the same session ; otherwise, one large treatment-room is more economical. The size of this room naturally depends on the number of patients likely to be treated.

The following rooms are necessary: treatment-room, dressing-, wash-, and waiting-rooms, matron's,

FIG. 105.—Plan of the "Sun-Ray Clinic," Newcastle-on-Tyne, from *The British Journal of Actinotherapy.*

nurses', and medical officer's rooms; an isolation-room, rest-room and surgical-dressing-room are also very convenient.

The room for treatment should be about 40 ft. by

20 ft., with a high ceiling, to allow efficient cross-ceiling ventilation, by means of hopper windows. Special ventilators can also be fitted behind the central-heating radiators, allowing air to enter the room, and be deflected upwards without causing draughts. These must be carefully avoided, as open arcs are very sensitive to air currents: to obtain smooth burning the air must be still.

The floor of the treatment-room can very conveniently be paved with "Granwood" blocks. These are a patent composition, which is durable, a good non-conductor, warm, non-inflammable and water-resisting. Linoleum is not satisfactory, because it is inflammable; concrete and terrazzo are too cold unless the patients wear wooden clogs, and wood flooring is not satisfactory.

The walls may be tiled for four or five feet from the floor, or made of terrazzo; or else the plaster, which should be of a specially hard variety, may simply be painted some sombre colour, which does not reflect the rays of visible light. A matt surface is preferable.

A sufficiently large waiting-room—about 20 ft. by 20 ft.—should be provided, and there should be easy access from it to the medical officer's room, and also to the dressing-room and wash-room. The treatment-room, dressing-room and rest-room must, of course, be adjacent to one another and on the same floor.

In the dressing-room separate pegs and lockers should be provided for each patient. The usual conveniences are also essential. In the wash-room there should be several shower-baths, with hot and cold water laid on, as in certain cases a shower—both

before and after treatment—is invaluable. Paper towels can be used with advantage, so as to avoid large laundry costs; soiled towels can be incinerated in one of the boiler-house fires.

The building should be heated by the low-pressure hot-water system, and it should be possible to regulate efficiently the temperature in the treatment-room. Independent boilers should be provided for heating the water for the showers, etc., and for the central-heating system.

A small storeroom for keeping towels, carbons, etc., is very useful.

The chairs used by the patients during the treatment should be of unpainted, hard wood, held together with brass screws, no glue being used.

The couches can be satisfactorily cleaned if covered with oilcloth. To avoid chill, a crêpe-paper sheet can be placed on the couch. One or two stretchers should be available, and couches provided in the rest-room.

Convenient control boards for the lamps should be placed on the walls at such a height that they are not within easy reach of the children.

Brown-paper shades, which can be easily made, and destroyed after use, should be provided for the protection of the patients' eyes. Special protective glasses should be worn by the staff. In the medical-dressing-room a few surgical instruments and syringes will be required, also a plentiful supply of dressings.

Fire extinguishers should be available.

The Choice of Lamps.—If in private practice it is desired to have only one lamp, a mercury vapour

lamp will probably prove most satisfactory. If the lamp is required for local treatment a "Kromayer" water-cooled lamp should be chosen; for general work, an air-cooled lamp.

In clinics and hospitals the carbon arc lamp is most often used, because it allows several patients to be treated simultaneously.

If direct current is available it should always be used, and preferably at a voltage of 200 to 250 volts. If only alternating current is laid on it is generally most satisfactory to install either a rectifier or a motor-transformer.

A comparison can be made between the carbon arc and mercury vapour lamps:

Carbon Arcs	*Mercury Vapour Lamps*
It is simple to obtain a constant output.	The emission of the mercury vapour lamp decreases with use.
Need a large amount of current.	Function satisfactorily on a small amount of current.
Carbons have to be constantly renewed; the changing of carbon takes time and soils the hands.	Burners have to be replaced only after 800 hours' use.
Are robust.	The quartz burner is rather fragile.
Give off fumes.	Do not give off fumes.
Small, red-hot particles are often thrown off.	No spluttering—even-burning.
Great heat developed.	Do not give off much heat.

Carbon Arcs	*Mercury Vapour Lamps*
A long exposure is needed.	Short exposure.
Useful for treating several patients together.	Most convenient for treating patients singly.
Most useful for general treatment.	Can be used for either general or local treatment.
Most valuable in the treatment of deep-seated tuberculosis.	Very useful in the treatment of rickets.
Most useful for the treatment of adults.	Most useful for the treatment of children.

Tungsten Arcs are very costly to burn, because of the high price of the tungsten electrodes, and, as they are hand-regulated, they can never be left when burning. They burn unevenly, and can be used on D.C. only.

Carbon Arcs.—If the long exposure required is no objection short-flame arcs can be used; otherwise, equally good results can be obtained with shorter exposures, using long-flame arcs.

There is no particular advantage in using lamps with several arcs burning in series, because the ultra-violet emission is exactly the same as with one arc taking the same wattage; and, though there is more heat given off, the cost of the carbons used is naturally greater.

Enclosed carbon arcs are often useful for treating children. Suitably impregnated carbons are preferred to plain ones, because they give off more ultra-violet rays.

The "Ajax" portable carbon arc lamp is useful for treating patients in their own homes.

Mercury Vapour Lamps.—Burners which light automatically are generally more convenient than those which have to be tilted. The "Henri George" burner can be used immediately after lighting.

The ultra-violet output from the "Atmospheric" burner is more constant than from the evacuated type, but not quite so powerful.

The number of watts used by a burner is some index of its ultra-violet-ray emission.

Most firms make burners which use different current voltages and ampèrages, and this should be remembered when a burner is being purchased.

There are two types of portable mercury vapour lamps which a doctor can conveniently use in the house of a patient who is unable to attend at his consulting-rooms. One of these is illustrated on page 113.

Choice of Lamp Housing.—Several of the existing types of lamp-housing are unsatisfactory, because they are made irrespective of the fact that the arc tube of the mercury vapour lamp is often six inches or more in length, and that therefore a rectangular or a parabolic, rather than a spherical, housing is required.

The Cost of running Different Types of Lamp:

Volts multiplied by ampères = watts.

1000 watts = 1 kilowatt.

1000 watts per hour = 1 kilowatt-hour.

1 kilowatt-hour = 1 Board of Trade Unit.

The price of the unit of electricity varies according

FIG. 106.—Our Suspension Housing, which is manufactured by Kelvin, Bottomley & Baird, being used for the Simultaneous Irradiation of both Nostrils. A cord fastened round the Patient's neck, and attached to the Lamp at each end by clips, maintains the Housing in position.

to the purpose for which it is used. There are usually different rates.

In Newcastle, for instance, there are three rates: the lighting rate costs 6d. per unit; the power rate, 3d. per unit; and the heating rate, $2\frac{1}{4}$d. per unit. Ultra-violet lamps are used at the power rate.

A mercury vapour lamp consuming 3 ampères at 240 volts uses 720 watts or ·72 kilowatts in an hour, at a cost of about $2\frac{1}{4}$d. an hour.

A carbon arc lamp consuming 30 ampères at 240 volts would use 7·2 units at a cost of 1s. $9\frac{3}{5}$d.

Position of the Lamp.—We have found the most satisfactory method of installing our lamps is to have them suspended from the ceiling and counter-weighted over pulleys, so that they can be easily raised or lowered as required and may be lifted out of the way when not in use. This proves a great saving of space, and also facilitates the cleaning of the room. It is an advantage if the lamp can be lowered as far as the floor, and also if there is sufficient room in which to move the couch so that different portions of it can be placed under the lamp. This does away with the necessity of having a swinging arm. Also the lamp should be placed at a sufficient distance from the wall to allow it to be brought over the centre of the couch.

The authors have designed a simple type of suspension housing which allows the radiation to be directed vertically downwards or horizontally outwards as may be desired. This housing can be used also for local treatment, with special applicators. We, however, generally find it more satisfactory to use the

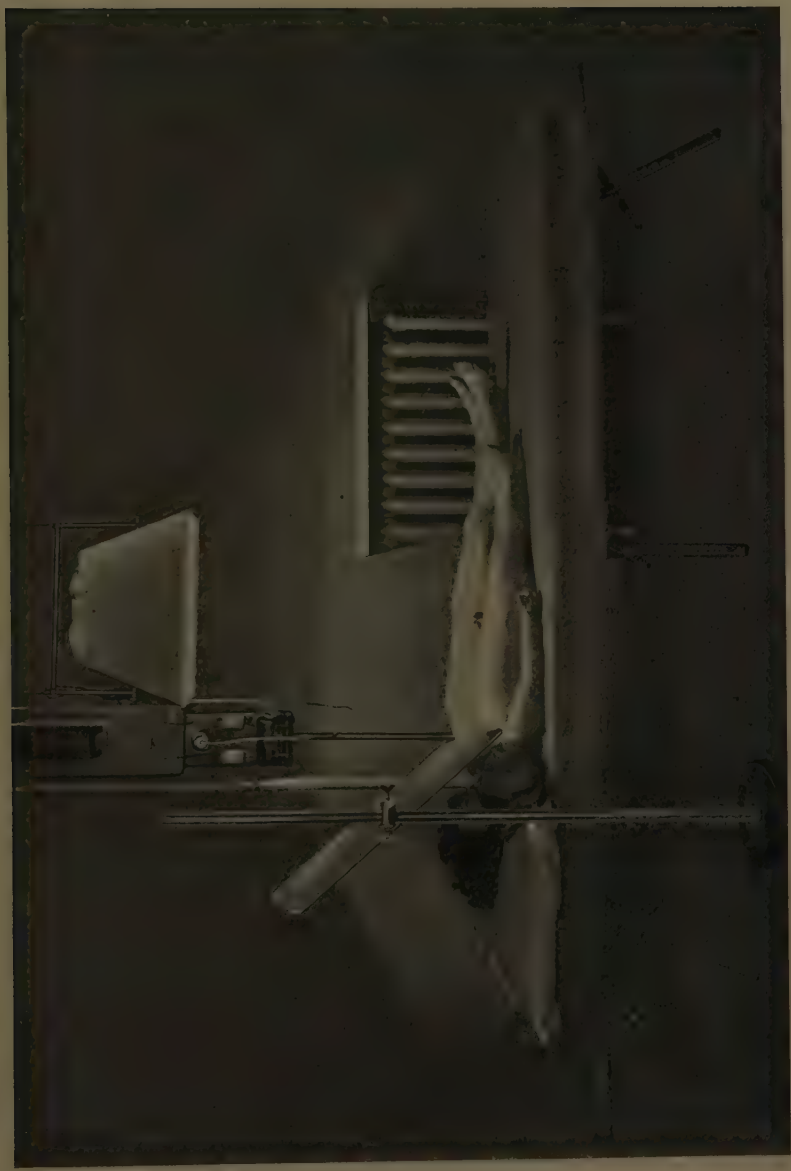


FIG. 107.—The Authors' Suspension Housing being used for General Irradiation. The Patients are lying on a Folding Camp Bed, which is placed near the hot-water radiator for warmth. The Adjustable Screen dispenses with the need for Goggles. The Lamp Resistance, a protected quick-break type of two-pole switch, and the Fuses are fixed at a convenient height on the wall near the couch.

lamp without diaphragms and cover the area which it is not desired to expose. Two overhead lamps give a more even distribution of the radiation than one. The authors' treatment couch, illustrated on page 123, is very convenient when it is desired to use two lamps together. The switch and resistance can be conveniently placed on the wall, so as to be easily accessible.

A protected quick-break type of two-pole switch is safest, and also most convenient, and the fuses should be of the replacement type, consisting of a porcelain plug containing the fuse, which can be readily withdrawn and inspected, and, if necessary, have the fuse wire replaced, without any necessity for turning off the current at the main. A supply of proper 15-ampère fuse wire is also desirable for 240-volt lamps and 20-ampère wire for 110-volt lamps.

There seems to be no particular time most suitable for administering ultra-violet radiation, and there is no danger in giving it after a heavy meal, as the erythema does not show itself until from four to eight hours after exposure. During and after irradiation the patients feel comfortably warm, but are not overheated, as the source of irradiation is relatively cold, so that there is no risk in going out of doors soon after treatment.

Air-cooled Mercury Vapour Lamp.—To obtain good results it is necessary that the lamp should be kept scrupulously clean. The quartz tube, as mentioned before, should never be touched with the fingers, as imprints become etched into the quartz and can never be removed. Cleanliness is best achieved by gently

rubbing the lamp with an old silk handkerchief moistened with alcohol. If direct current is available, it is preferable to use it with the mercury vapour lamp. With alternating current a rectifier has to be used; this does not however apply to the special type of burners made for use with the alternating current by the Hanau and British Hanovia, "Quartz Transparent," "Silectra," Ulbrich and Gallois companies. With both forms of current, resistance is necessary to cut down the current to about 15 ampères. The current must always flow in the same direction—if it is reversed the lamp will be destroyed—so the plugs are usually made non-interchangeable to avoid mistakes.

Method of Lighting Lamps.—Burners which are unprovided with an automatic method of ignition, when all connexions are secure, must be tilted by raising the positive end, in order to cover the negative-end electrode with mercury, and then lowered. The current is then switched on and the lamp raised as before. As soon as the mercury again touches the negative electrode the arc is struck and a brilliant illumination results. The burner is now lowered to its original position. At first the light is rather dull, but after a few minutes it reaches its maximum intensity. The voltage of the current rises continuously and the ampèrage falls while the lamp burner is heating up. A very small fall in voltage can cause a big drop in intensity of the ultra-violet emission.

By exposing strips of printing-out paper for one, two or three, and up to ten, minutes respectively, and comparing the different tints, we noticed that the

"Hewittic" lamp attains its maximum intensity five minutes after lighting, and remains constant thereafter. Therefore the lamp should be allowed to burn for five minutes before commencing treatment. On exposing a strip of printing-out paper the same length as the burner, parallel with and directly below it at a distance of about three inches from the burner, we found that the greatest amount of ultra-violet rays were given off from the centre.

It has already been mentioned that it is unnecessary to tilt the "K.B.B." quartz mercury vapour lamp to start it. Like the "Hewittic" lamp, five minutes must elapse before the constant maximum irradiation is obtained, but the "George" and high-frequency burners are ready for use in a few seconds.

It is undesirable ever to alter the lamp housing, as the adjustment of the temperature of the mercury in the lamp is critical, and the housings provided have been specially designed to keep the temperature of the mercury below boiling-point.

It has been shown that external cooling plays an important part in the character of the arc, and this fact explains why mercury vapour lamps fitted with unsuitable housings sometimes get overheated and go out. When overheating occurs the resistance of the mercury vapour column is greatly increased, and a higher voltage is needed to maintain the arc; if this is not available the lamp is extinguished, and restarts only when it is cooler. A similar effect occurs with the carbon arc lamp when the arc has become too long. A relatively large amount of current is needed to ignite the mercury vapour lamp when it is cold;

and the low vapour pressure in the tube requires only a low voltage.

The vapour pressure and volts rise with the elevation of temperature, but the amount of current passing decreases. A uniform intensity of radiation is given off when the vapour pressure remains constant, and the electrical expenditure balances the heat radiation from the burner; burner ventilation and room temperature influence the radiation from the latter.

Contra-Indications to Actinic Treatment:

(1) If the temperature is high.
(2) Grave heart disease where compensation has broken down.
(3) Acute nephritis.
(4) Severe cases of arterio-sclerosis.
(5) Cases of very acute eczema.
(6) New growths should never be locally irradiated.

The Treatment should be discontinued if:

(1) The temperature is raised after irradiation for more than 24 hours.
(2) The patient is regularly losing a large amount of weight (except in obesity cases).
(3) The patient is excessively nervous after the first two applications.
(4) The treatment is followed by severe depression.
(5) In psoriasis an acute eruption develops.
(6) Menstruation is present. (This is customary, but not essential.)

Great care should be taken when the following cases are irradiated:

(1) Cases who have had hæmoptysis.
(2) Amyloid degeneration.

"*Violet*" *and Ultra-Violet Rays.*—At present there is great confusion in the public mind between the two terms "violet rays" and "ultra-violet rays," and they are continually being confounded. Violet rays is the popular name given to the vacuum electrode discharge from small monopolar high-frequency sets often used by hairdressers and "beauty specialists." Even used in this sense the expression is an unfortunate one, as the colour of the vacuum tube in use depends entirely on the degree of exhaustion of the tube; and, of course, ultra-violet rays are invisible and glass absorbs all the important ultra-violet rays.

Are Ultra-Violet Rays dangerous?—Recently fears have been expressed that the continued exposure of the operator to ultra-violet radiation might cause conditions similar to those produced by continued exposure to X-rays.

Dr Axel Reyn, head physician at the Finsen Institute, Copenhagen, however, writes as follows:

"I read with the greatest interest Sir G. Lenthal Cheatle's letter in the *B.M.J.* of 28th March, in which he states that, together with Dr Arthur Whitfield, he has examined skin that has been 'bronzed' by therapeutic exposure to sunlight and has found mitosis occurring in the epithelial cells situated above the basal layer, from which he seems to conclude that there may be some risk of inducing epithelioma by exposure to sunlight or artificial irradiation. It is true that atrophic changes are sometimes observed in the skin of persons whose hands and faces are habitually exposed to strong light and air, and that in such cases epithelioma is sometimes seen

to develop on the exposed parts. But up to the present nothing whatsoever has been brought forward to prove that it is the light particularly that produces these changes. From all indications the lesions are much more likely caused by such influences as wind and rain and all the various assaults to which the constantly uncovered and unprotected skin of these persons is daily exposed. Do we not see epithelioma of the skin develop in almost any site exposed to constant mechanical influences? We need only think of cancer of the lips, chimney-sweeps' cancer, tar cancer, and many others besides.

"That the therapeutical application of light should produce epithelioma is in the highest degree unlikely. Nothing argues more strongly against this suggestion than the fact that up to this day not one single case of cancer of the skin has been reported as caused by the light bath, among the hundreds and thousands of persons who take either sun or artificial baths of this kind. I may state, furthermore, that among the thousands of patients who have received local phototherapeutic treatment for lupus at the Finsen Institute we have not observed one case of lupus carcinoma resulting from this treatment. On the contrary, the percentage of lupus carcinoma shown by our records is the lowest existing; a fact which must be ascribed exclusively to the phototherapeutic treatment, which cures the patients so that they do *not* get carcinoma, while, if the light were particularly provocative in this respect, we should, of course—on the contrary—see a great many cases of this complication.

"I see yet another proof in the conclusions arrived

at by Dr K. A. Heiberg, the histologist at the Finsen Institute, as the result of microscopical examinations made of the skin of twenty-five patients who had been under treatment with carbon arc light baths for a considerable period. Not in a single instance did Dr Heiberg observe any change involving risk of epithelioma; on the contrary, he proved that a vigorous regeneration of healthy skin takes place which greatly assists in improving the functioning of the latter. I therefore urgently recommend the use of light baths, sunlight or artificial, in all diseases in which this treatment is suitable. It is a therapy which has already proved so rich in beneficial results that it should be used, also, in the future, to an ever-increasing extent; and we certainly must not allow ourselves to become frightened of dangers that are non-existent."

Symptoms which may follow Irradiation.—If insomnia should occur after treatment it is almost always due to pruritus, associated with erythema. A few patients have their nervousness aggravated by irradiation, and headache sometimes occurs after exposure. In very rare cases anaphylactic symptoms may be manifested.

Severe burns, such as sometimes unfortunately occur as a result of galvanic, faradic or diathermy treatment, are unknown with ultra-violet radiation. The word "burn" is not a strictly correct one to use when describing the skin reaction caused by ultra-violet rays. The term "actinic-erythema" is much more appropriate.

If, however, the red-hot arc tube is touched,

burning may occur. Quartz is such a good insulator that there is no danger of electric shock.

A Case of Over-Exposure.—Great care should be taken to prevent patients from administering ultra-violet treatment to themselves. Dr MacCormac and Dr McCrea describe in *The British Medical Journal* of 11th April 1925 an instructive case which came to their notice of the very serious consequences that resulted from excessive exposure in a patient who was taking light baths without medical advice. This patient was accustomed to have a daily artificial sun bath of ten minutes' duration—this he usually had whilst lying on his back in bed. One day while having his light bath he fell asleep, and the lamp continued to play on him for an hour and ten minutes. Severe erythema and desquamation followed.

Twelve days later a general erythema of the trunk and extremities was noted. Urticaria developed, the irritation of which kept the patient awake. Five days later the patient became restless and disturbed; cardiac extra-systoles developed, and the patient continued to be gravely ill for four days and then rallied. The skin, however, continued to be affected, desquamation went on, and a fortnight later an extensive purpuric eruption developed on the legs. After this the patient's convalescence was uninterrupted.

This accident happened in an extremely simple way, as the rays are very soothing and conducive to sleep.

It emphasizes the necessity of ultra-violet radiation being applied solely under the personal supervision of qualified medical practitioners.

In properly supervised ultra-violet radiation the greatest harm that can result is the formation of a blister.

Only the superficial layers of the epidermis are shed, the true skin is never destroyed.

Administration of Treatment.—Many patients are

FIG. 108.—Children being irradiated with the Air-cooled Mercury Vapour Lamp surrounded by a ring of Carbon Filament Lamps.

apprehensive at the thought of undergoing any new form of treatment, especially if they think it is to be electrical treatment, as this to them can often mean only one thing—namely, the small faradic coil—so it is always advisable to stay with the patient during the first application, and with nervous people during each treatment. It is a good thing to tell the patients that all they will feel during the treatment is a sensation of warmth accompanied by slight tingling, and

a feeling of freshness very similar to the effect of sunshine, except that the heat is less.

Before commencing treatment it is always wise to ask patients if they are unduly sensitive to sunshine, and also to test the urine, for albumin, sugar or hæmatoporphyrin.

A clock with a strong alarm is a great asset, as it enables one to attend to other duties whilst the patient

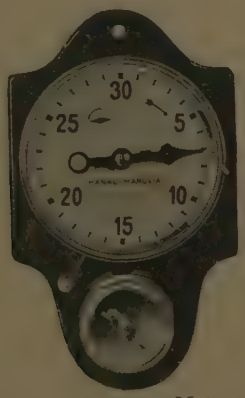


FIG. 109.—Exposure Meter with Alarm Bell. (Wall Type.)

is being irradiated. Clocks can be obtained which can be set for any length of time from fifteen seconds to an hour. We have found the wall type the most reliable.

They are the means of saving a great deal of time, but extreme care must be exercised in seeing that the alarm is properly set and free to ring at the desired time, otherwise overdosage may result. Of course the alarm clock is not absolutely necessary, but we find that it obviates the constant looking at one's watch which otherwise must be unavoidable.

It is advisable to warn the patient that the flesh will assume a purplish colour in the light—especially mothers whose children are having treatment—and that the mucous membranes will appear black, owing to the light of the mercury vapour lamp being deficient in red rays.

Every patient should be warned of the probable appearance of the erythema in a few hours, and also of simple remedial measures, such as applying olive, carron or castor oil, if the reaction has been sufficiently intense to cause discomfort and tenderness. However, it should be made clear that it is much better not to apply anything unless it is absolutely necessary, as it tends to prevent the penetration of the radiation at subsequent exposures. It is not advisable to bathe the irradiated part for about twenty-four hours after exposure.

It is of great importance that both the patient and operator should have their eyes adequately protected, as even a few seconds' direct exposure will cause a severe conjunctivitis, which, although it may pass off after a few days, is extremely painful.

Crookes' or some similar glasses should always be used.

Patients should be warned never to look at the lighted lamp when they are undressing preparatory to treatment. We specially mention this because recently two adult patients of ours did this out of curiosity; one felt no ill effects until he was awakened from his sleep the same night with intense pain in his eyes; he was unable to see, and was confined to his house for three days before the reaction subsided.

The other had a somewhat similar experience, and was attended by his own doctor's locum, who was newly qualified, and could not make up his mind definitely whether the intense inflammation of the face was due to erysipelas or whether it was a case of scarlet fever.

The patient's face may be covered, if preferred, with an oblong piece of cardboard, having elastic or

FIG. 110.—The "Wellsworth Hardy" Goggles, which can be fitted with Saniweld, Noviweld or Pfund Lenses. The frame is made of Condensite, which is a non-conductor of heat and electricity, and ventilation is arranged so that no side light can reach the eye.

tapes fastened to its two upper angles. An opaque fan or similar object can also be held by the patient over the face—but glasses are generally used. The operator's goggles should be provided with efficient side ventilation to avoid steaming, which soon results if this precaution is neglected. Glasses used for electric arc welding can easily be obtained.

Numerous cases are on record where men engaged in arc welding have suffered from severe traumatic conjunctivitis following exposure to ultra-violet radiation. The symptoms usually are photophobia, excessive lacrymation and intense smarting of the lids, with contraction of the pupil. Sometimes, swelling of

the lids, with the formation of corneal ulcers, iritis and retinitis, may result.

If this condition ever should occur after exposure to ultra-violet rays, ice-packs should be placed over the patient's eyes three or four times a day for periods of fifteen to sixty minutes, and the eyes irrigated with a saturated solution of boric acid several times daily. If pus is present, argyrol or protargol can be used. The patient should be confined to a darkened room, and if intense pain be present morphine administered.

If the air-cooled lamp is being used in local applications, the normal skin surrounding the lesion and other exposed parts must be protected. This protection of the surrounding parts may be effected by smearing over them some absorbent ointment. There are several preparations: "Antilux" contains two per cent. Beta-naphthol in a lanoline base; an ointment made with æsculin, a glucoside found in the bark of the chestnut-tree; an ointment made of paraffin molle, lanoline and finely powdered wood-charcoal; a pomade containing collargol; or paraffin molle and tannic acid.

Or, again, the skin may be painted with some dark pigment mixed with soft soap, which can be washed off easily after treatment.

Black or red paper, cardboard, adhesive plaster, or thin lead-foil, which is very malleable, and can easily be obtained from any tea-dealer whose tea-chests are lined with this material, may be used.

It must be remembered in this connexion that clothing materials which are partly transparent to ordinary light are also penetrable by ultra-violet

rays. This is of importance when children or ladies are being treated, as exposure of surfaces not intended to be irradiated could easily result in the occurrence of erythema in undesired places. The hoods of most lamps are, however, provided with diaphragms which enable one to localize the rays.

Women generally use loin slips during treatment; these can easily be made. Care should be taken to ensure that the same area of skin is always covered. Some "Antilux" or vaseline should be applied to the nipples before irradiation.

To avoid the discomfort of recurring erythema and consequent desquamation, if the operator's skin be at all sensitive, it is wise to wear a hood and gloves to protect the exposed parts. The hood can conveniently be made of some thin black material and have apertures for the eyes, which should be covered by protective goggles.

Before irradiation the skin should be thoroughly cleaned, and all greasy matter or powder must be removed. Scales and crusts must also be dislodged, and if the application is to the scalp the hair must be kept as short as possible, as each hair may cast a shadow over the affected part. The great power of absorption of practically all substances for ultra-violet rays, especially the short bactericidal rays, must always be remembered.

In deep-seated skin lesions, and especially in the case of lupus, where the maximum amount of rays is required to penetrate the tissues, it is advisable to use a quartz compressor to make the part anæmic, and thus prevent the absorption of the rays by the blood.

During the winter it is sometimes desirable to apply a hot-water bottle, or, better still, an electric heating pad, to the patient's feet.

It is advantageous not to relight the lamp for each

FIG. 111.—Small Children undergoing Ultra-Violet Irradiation.

new patient. It is far better to allow it to burn continuously, so that the lamp is available for immediate use. Incidentally, damage is most likely to accrue to the lamp from repeated relighting at short intervals. Of course the burners have only a certain life, and should not be left burning unnecessarily.

For general treatment, it is best to expose a com-

paratively small area at the first application, but after that to irradiate as large an area of the body as possible —the whole of the back and the whole of the front on the same day—as there is no doubt that the effect obtained in most cases is increased by exposing the maximum skin area to the irradiation.

Another method of general irradiation which is frequently used is one in which the first exposure is given to the feet, the second to the feet and calves, the third to the feet, calves and thighs, etc.; the longest exposures always being given to the parts which have been exposed first, until the whole body is exposed. The term "fractional irradiation" is applied to this method.

It is thought by some authorities that irradiation of the extremities leads to decongestion of the viscera, and similarly that irradiation of the trunk leads to congestion; so that in such cases as phthisis, where visceral congestion is contra-indicated, the extremities only are exposed to the rays.

When giving general treatment it is usually wise to cover the back of the patient's head with a light towel when he is lying in the prone position, especially if he suffers from headaches.

The ozone generated by the mercury vapour lamp can be used for inhalation; large amounts are formed particularly when the lamp has just been lighted. The ozone should be inhaled for about a quarter of an hour, at a distance of about twenty-four inches from the lamp.

Raying Children.—The first application of the rays to a child should be given with the child in its mother's

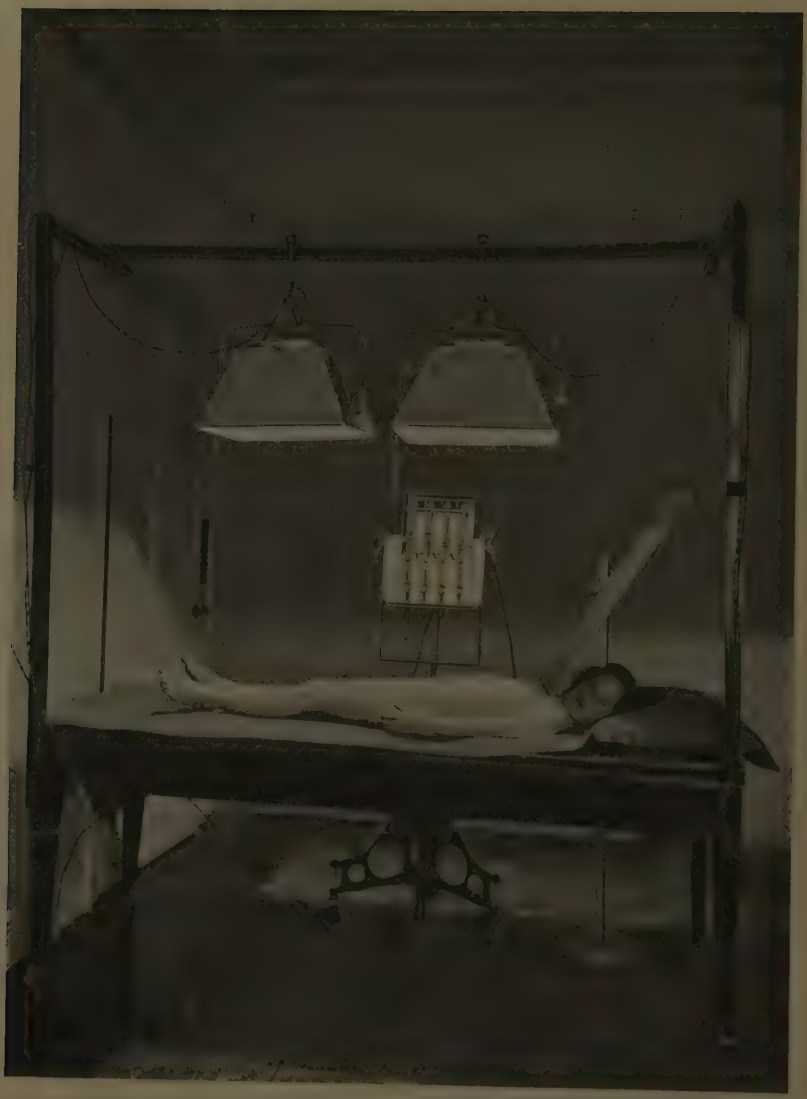


Fig. 112.—An early type of Treatment Couch used by the Authors, which they have now replaced by the type illustrated in Fig. 76. The photograph illustrates the simultaneous use of two Mercury Vapour Lamps and a Multiple Carbon Arc Lamp. The Mercury Vapour Lamps are suspended by hooks from a Ladder Chain, which allows them to be lowered when required. The chains are attached to Wooden Rollers which can move along the Horizontal Wooden Rail. The Authors' Screen is in use instead of Goggles. The disadvantage of this type of couch is that it is difficult to use it for Local Treatment.

arms, until confidence is gained, when there will be no difficulty in getting it to lie on the couch. Small infants can easily be irradiated on the mother's knee. Great care is necessary to protect their eyes and to prevent them taking off the protective glasses.

The authors have designed a simple appliance which they find invaluable; it consists of a weighted stand with an adjustable screen of three-ply wood. In general treatment it entirely obviates the necessity of wearing goggles, and it also prevents erythema or pigmentation masking the normal appearance of the face.

In hospitals, where a large number of children have to be irradiated daily, it is a great convenience to have several lamps installed in one room, with reflectors arranged to direct the rays into the centre of the room. Children of a similar height are treated together, and the lamps are adjusted so that the rays are directed towards the centres of their bodies.

Concentric circles of measured radii are permanently marked on the floor, and the lamps placed on the outermost of these. During treatment the children walk round on a definite circle corresponding to the dose required at that application, allowing the whole body to be irradiated at once.

The walls of the treatment-room should be white-washed so as to get as much reflection of the ultra-violet rays as possible.

The Position of the Patient during General Treatment.—The patients may stand for treatment, or sit down, or assume the recumbent position.

If the exposure is to be a long one, the standing position will naturally not be satisfactory.

With the carbon arc lamp patients usually sit on chairs, whose seats are about seventeen inches from the ground; they sit as close together as possible, and as near the lamps as the heat allows, but it is

FIG. 113.—Irradiation of Children with "Jesionek" Quartz Mercury Vapour Lamps at a General Hospital. (Note the Dosage Circles described on the floor.)

generally impossible to make the distance between the positive crater and the middle of the patient's back less than eighteen inches. The whole body is exposed to the rays, and the greatest intensity of radiation is allowed to fall on the trunk, which presents the largest surface area. The maximum

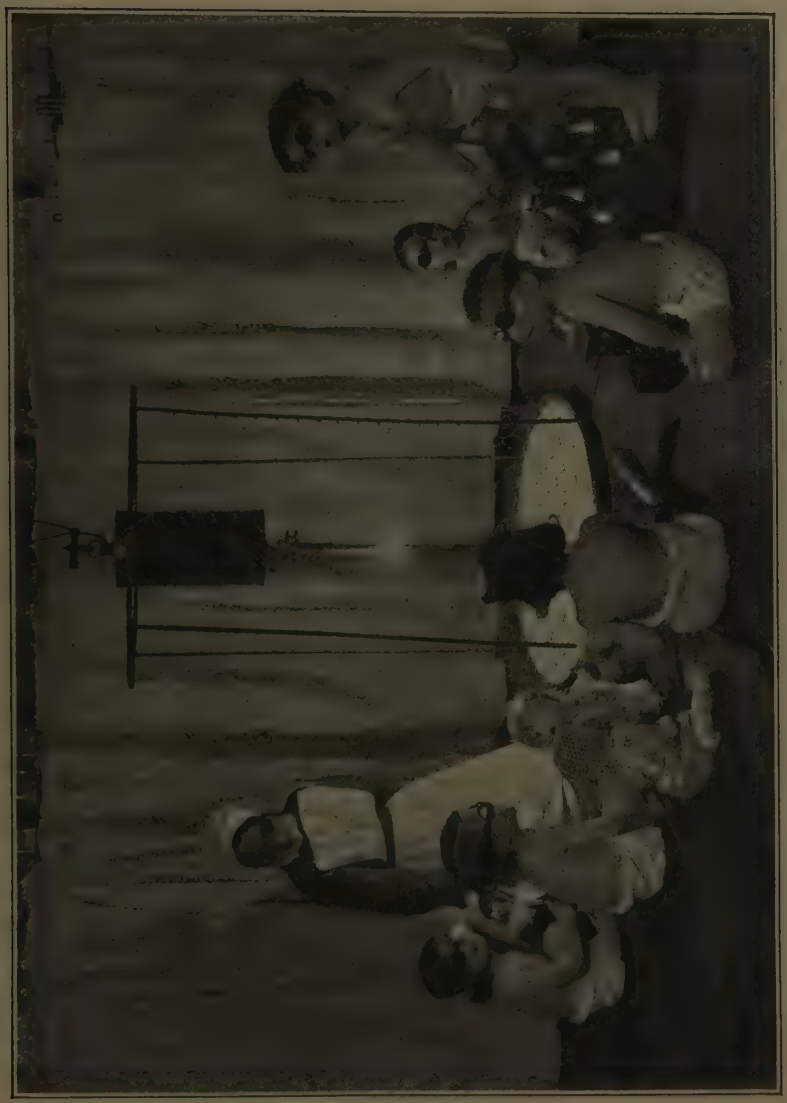


FIG. 114.—Children being irradiated with the "Westminster" Long-Flame Carbon Arc Lamp at a London Hospital.

radiation is given off from the positive crater of the short-flame arc at an angle of about forty-five degrees to the axis of the negative carbon, and these rays should fall on the patient's body at the subcostal

FIG. 115.—General Treatment at the Finsen Institute, Copenhagen, for Sitting Patients, with two 75-ampère Carbon Arcs in parallel.

margin. Six to eight patients can be treated at one time with two 75-ampère lamps.

The middle patient on each side receives the greatest intensity of radiation, so that it is customary for them to change places from time to time. During treatment the back, sides and front of the body are all exposed in turn.

Couches should be provided for those patients who are unable to sit comfortably, and in this case it is customary to use three 20-ampère arc lamps in series arranged in a straight line between two couches, so

FIG. 116.—Patients at the Finsen Institute, Copenhagen, receiving General Treatment with the 20-ampère Carbon Arc Lamps.

that two lying patients can receive treatment at the same time.

As considerably less heat is given off by these lamps it is possible to get much nearer the arcs. The patient lies first on his back and then in the prone position.

With the long-flame arc the greatest ultra-violet emission takes place from the flame itself, so that when a sitting patient is being treated with this type

of lamp the arc flame should be at the same level as the patient's trunk. A recumbent patient should lie on his side during treatment with this lamp, first facing the lamp and later with his back to it, the arc being just above the level of the couch top.

With the mercury vapour lamp it is quite true that it would ensure even distribution of radiation if the patient, during the first six applications, assumed a curved position approximating to part of the circumference of a circle with a radius of three feet, but later, when the distance between the patient and the burner had been decreased to one foot, the assumption of the hypothetical curved position required would naturally be quite impossible.

The satisfactory solution is undoubtedly the utilization at the same time of two mercury vapour lamps for each patient. We prefer to have the patients lying on couches, with the lamps suspended directly above them, their arc tubes being parallel with the patient, who first lies in the supine and then in the prone position.

It is an extremely rare occurrence for a quartz burner to burst while in use, and even if one did, all that would result would probably be some slight burns caused by the hot pieces of quartz falling on the skin.

If the "Jesionek" type of lamp is used the patient can lie on his side, first facing the lamp and then with his back to it.

Certain enclosed carbon arcs with inclined carbons can be suspended directly above the patient.

With the "Arnold" lamp the effective rays are

FIG. 117.—Simultaneous Irradiation of the Front and Back of the Body with two "Hospital Type" Saidman Carbon Arc Lamps.

given off obliquely in exactly the same way as from the short-flame arc. This, we know, is contrary to what is frequently stated: it was proved to our satisfaction when we noted the level at which erythema, and later pigmentation, occurred on the back of a patient who was treated in the upright position.

Treatment may be applied simultaneously to both sides of the body by means of two carbon or "Jesionek" lamps, the patient either lying on his side on a couch or sitting on a small stool facing one lamp and with his back to the other. This halves the usual time needed for treatment.

For Local Treatment it is generally easy to arrange the patient in a convenient position; a head-rest and sandbags are very useful.

The lithotomy position is very convenient for irradiating the vaginal and pubic regions, and either this or the knee-elbow position may be used for anal affections. We have found the greatest difficulty in treating eczema affecting the inter-natal area, and have had a small instrument made to secure mechanical separation of the cheeks of the buttocks.

In treating scalp conditions the back of the neck and ears of the patient must be carefully protected with a towel held in position with clips.

In all local treatment the surrounding areas must be adequately protected.

The Use of Ultra-Violet Rays in the Operating Theatre.—The authors recently saw at the Hospital Necker (Paris) a special ultra-violet lamp, suspended over the operating-table, which Professor Leguen and Dr Saidman have been using during the performance of

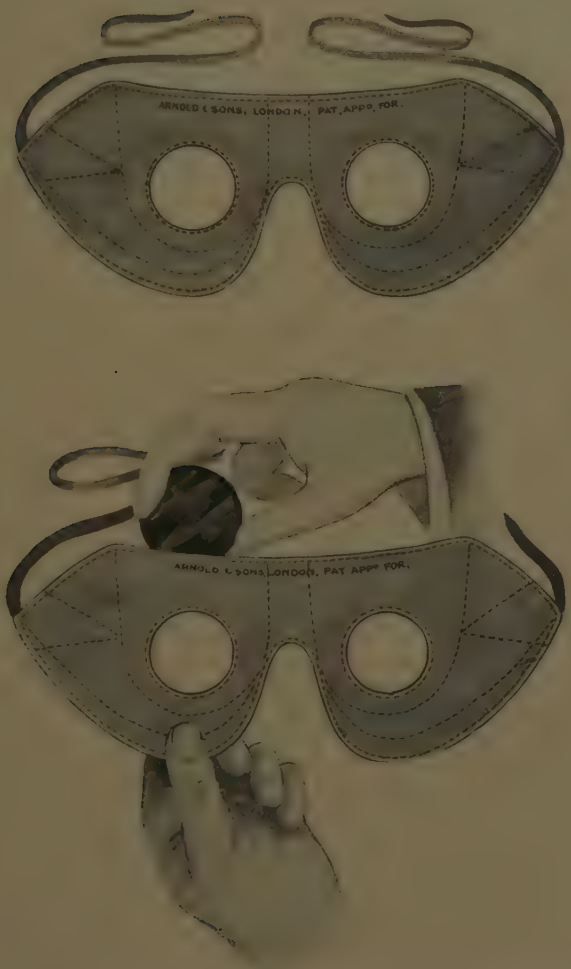


FIG. 118.—Protective Goggles with Removable Glasses which can be easily sterilized by boiling.

operations. The rays fall directly on to the wound, and have been found a help rather than a hindrance to the surgeon during the time of exposure, because of the good illumination which results.

Dosage.—Dosage is dependent on so many different factors that it is very difficult to lay down definite laws as to the length of exposure. The radiation from the lamp depends on :

(*a*) The primary source of illumination.

(*b*) The different media through which the rays have to pass.

(*c*) Whether a special filter is being used.

Lamps operating on 240 to 480 volts are much stronger than those designed for 110 volts. One type of "George" burner is seven times stronger than another. Secondly, it depends on the age of the burner. A new burner is more brilliant than one which has been in use for some time. The reason for this has been explained in Chapter V. The number of lamps employed is also of consequence.

Another important factor in dosage is the sensitiveness of the patient. No two patients are alike. One would have a severe reaction with an exposure which would cause only the slightest reddening in another person. Generally speaking, dark types can stand a longer dosage than fair, and the reddish type is the most sensitive. Children can stand about half the dose of an adult male of a similar type.

Women are as a rule more sensitive than men, and sensitiveness decreases as age increases. The parts of the body exposed to light—hands, face—are much less sensitive than the regions covered by clothing.

TABLE SHOWING THE RELATIVE SENSITIVITY OF DIFFERENT PARTS OF THE BODY (*After* PACINI)

Part	*Relative Sensitivity*
Chest	1
Abdomen	1
Back	1
Groin	1
Anterior arm	$1\frac{1}{2}$
Posterior arm	$1\frac{3}{4}$
Posterior leg	$1\frac{3}{4}$
Anterior leg	2
Dorsum of hands	5
Palms of hands	15
Soles of feet	25

Another important point is whether the epidermis is thick or thin, and whether it perspires easily or not. Thin, dry, pale skin reacts more readily than fat, moist, pigmented skin.

Children seem to respond more readily to ultra-violet radiation than adults, and this is probably partly because the horny layer of the skin is not so thick as it is in the case of adults.

In practice, however, we have always found an initial dose of two and a half minutes at a distance of thirty-six inches to be a safe one, whether the patient is a child or an adult.

The strength of a lamp can be standardized either by its power to darken photographic paper (as compared with a standard shade), or by its power of bleaching a solution of acetone methylene blue. In this method a little of the solution is placed in a small

quartz tube and exposed to the rays from the lamp at a certain distance for a certain length of time. The shade of the solution is then matched with a series of eight solutions of gradually paling shades in small glass tubes, and the number of tubes between the original shade and the faded shade noted.

In practice elaborate tests are unnecessary.

The intensity of the ultra-violet radiations varies with distance in the same proportion as does ordinary

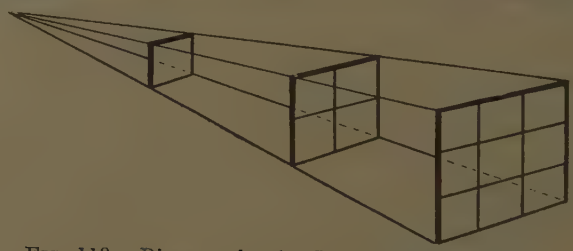


FIG. 119.—Diagram showing Law of Inverse Squares.

light—*i.e.* the intensity varies inversely with the square of the distance from the lamp. Thus, if the radiation falling on a certain area at a distance of one foot from the source is taken to be one, the amount falling on an equal area at two feet will be only a quarter, at three feet a ninth, and at four feet a sixteenth, and so on. This shows the imperative necessity of always carefully measuring the distance of the patient from the burner of the lamp. Some lamps are conveniently provided with a fixed steel-spring tape-measure, but an ordinary tape-measure will do almost as well.

Great care should be taken when a new burner is being used, as they are exceptionally powerful during the first twenty-four hours of use.

The cases of over-exposure which sometimes occur are generally due, not to the actual length of the exposure in seconds, but to a failure to measure the distance of the patient from the lamp. This measurement should invariably be made before commencing

FIG. 120.—Photograph showing Varying Degrees of Erythema produced by Graduated Exposure of Different Areas on Forearms to Ultra-Violet Rays.

treatment. Especial care should be exercised with the first treatment, as the patient may be one of those susceptible people who have an idiosyncrasy to ultra-violet radiation.

If over-exposure should occur, smaller subsequent doses should be given. Vaseline or zinc-oxide ointment

may be applied, and blisters treated with a ·5 per cent. solution of resorcin.

One point which deserves notice, however, in regard to the length of exposure is that, if for any reason a patient has missed treatment for a period of ten days, it is safest to recommence with half the last exposure; if, however, three weeks or more have elapsed it is as well to begin again with the initial dosage.

The sensitiveness of the patient may be judged by placing over the forearm a piece of material in which are several holes which can be covered after exposure. The first hole is exposed for one minute at a certain distance (thirty-six inches in the case of the air-cooled lamp), the second for two minutes, etc., up to five minutes. The following day the degree of erythema is noticed, and therapeutic exposures given accordingly.

The Eidinow Test-Dosage Armlet is useful and convenient for making these tests.

The erythema varies and may be classed in four degrees of severity; the doses mentioned refer only to an average air-cooled mercury vapour lamp:

(1) Very slight degree of reddening, not followed by desquamation of the skin, obtained on an average of one or two minutes at 36 in. from the lamp, increasing one minute daily.

(2) Slightly more reaction, accompanied by mild irritation and followed by fine desquamation. Two and a half to three minutes at 36 in., and increasing as shown on the scale.

(3) More severe reaction, accompanied by itching and burning, and later by free peeling of the skin. Five minutes at 18 to 20 in.

(4) Destructive reaction in which there is swelling and blister formation, seven or eight minutes at 18 in. to 1 ft.

This dosage is the average and must be modified as explained previously. It is obviously important to consider whether stimulation or irritation of the part treated is desired.

Degrees (1) and (2) are used in cases where general irradiation is required for constitutional conditions such as neurasthenia or after severe illnesses for tonic effect, etc. The length of exposure may be gradually increased during the whole course of treatment as the skin pigments, even to half-an-hour back and front, or longer, care being taken that the increase is gradual. Degrees (3) and (4) are used for local conditions such as lupus, nævus, etc., where destruction of abnormal tissue is desired.

SUGGESTED DOSAGE SCALE FOR USE WITH AN AVERAGE AIR-COOLED MERCURY VAPOUR LAMP (220-240 VOLTS) FOR GENERAL ULTRA-VIOLET IRRADIATION

No. of Application	*Duration of Exposure to each Side of Body*	*Distance from Source of Radiation*	*Relative Strength of Dose*
1st	2½ min.	36 in.	1
2nd	3½ ,,	36 ,,	1·4
3rd	5 ,,	36 ,,	2
4th	6½ ,,	36 ,,	2·6
5th	8 ,,	36 ,,	3·2
6th	10 ,,	36 ,,	4
7th	10 ,,	30 ,,	5·76
8th	10 ,,	24 ,,	9
9th	10 ,,	18 ,,	16
10th	10 ,,	12 ,,	36

For a first-degree reaction slightly smaller doses should be given, and for a second-degree slightly larger.

The makers of the "Henri George" burner suggest the following dosage scale:

	110 *volts*	220 *volts*	
1st application	4 min.	$2\frac{1}{2}$ min.	To each side of the body at a distance of 3 ft. from the burner
2nd ,,	6 ,,	4 ,,	
3rd ,,	8 ,,	6 ,,	
Never exceed	45 ,,	30 ,,	

Augment dose by two minutes at each application.

At the first glance this dosage seems stronger than that on page 247, but this is not the case, because the final dose is only twelve times more powerful than the initial one, whereas on our dosage scale it is thirty-six times stronger, and also a great deal of valuable time is saved.

The skin is more susceptible to ultra-violet radiation than mucous surfaces.

Cosine Law.—Wherever possible the patient should be placed so that the rays from the lamp strike the part which is being irradiated at right angles, as intensity is lost if the incident angle is less than a right angle. The law governing this loss of intensity is known as the "Cosine Law." The period of exposure must be lengthened in proportion to the size of the angle of incidence. An unequal effect is produced by radiation of convex surfaces such as the shoulder, the action of the rays, as already mentioned, being strongest where they strike the surface at right angles. When raying a large area, endeavour should always be made to cause equal distribution of effect; the

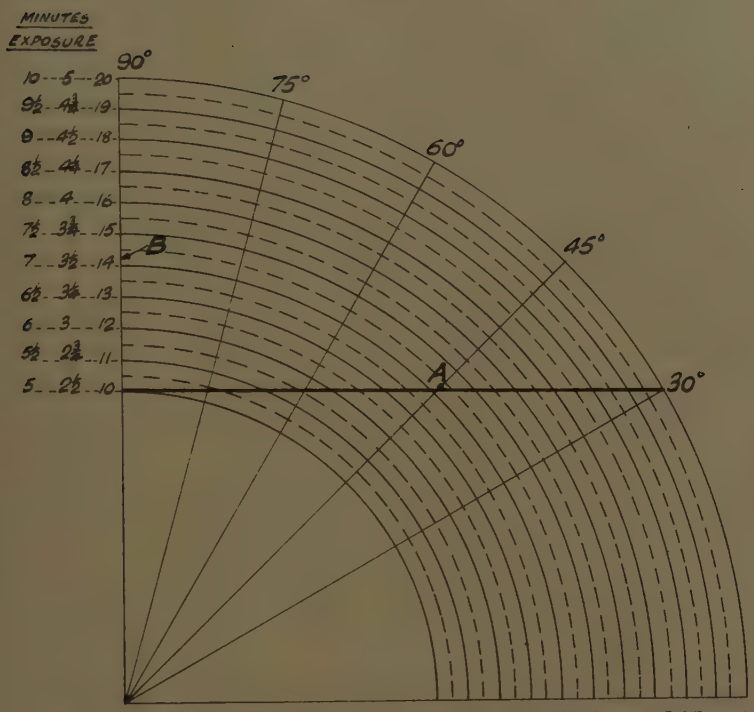


FIG. 121.—Chart showing Dosage required for Irradiation at Different Angles of Incidence.

Example.—Assuming that the lamp is to be used at an angle of 45° to the patient, follow down the 45° line until the point A is reached, then follow round the curved line to the point B, and read the figures there—viz. 7, 3½ and 14 minutes respectively. So that assuming the exposure to be 2½ minutes when the lamp is directly over the patient (or at 90°) then the time required to produce a similar effect at 45° would be 3½ minutes, or when 10 minutes at 90°, 14¼ minutes at 45°, allowance being made for the fact that the point B is a quarter of the distance between the figures 14 and 15 on the scale. In the same way the proportionate exposure required at any angle can be found on this chart.

simultaneous use of two lamps is advantageous in this respect.

Intervals between Applications of Treatment.—First-degree erythema doses can, if desired, be given every day ; second-degree doses are applied generally every other day, or twice a week.

Some cases do well with weekly doses, particularly chronic cases, such as hyperpiesis.

In general treatment it should be a rule never to apply radiation when the reaction from the previous treatment is still present.

After twelve to twenty applications some actinotherapists prefer to make a rest interval of three to four weeks, but this is quite contrary to the opinion of the Finsen Institute authorities—and, after all, they have had most experience of ultra-violet treatment.

Duration of Treatment.—When the rays are applied for their tonic effect twelve applications will sometimes suffice. For other conditions the nature and severity of the disease are important factors.

In rickets at least twenty-four applications should be given, and in cases of sterility thirty-six applications. Naturally, treatment is generally prolonged in cases of surgical tuberculosis.

Local Treatment with the Water-cooled Mercury Vapour Lamp.—The water-cooled lamp is so powerful that it is always wise to become familiar with the air-cooled lamp first.

Moreover the air-cooled lamp is generally much more useful than the "Kromayer," which probably will be required only by a specialist.

The lamp can be removed from its stand and used

to "iron" the affected parts, but this method is not very satisfactory, because it renders exact dosage difficult. The lamp is much more often used in the fixed position, either clamped in its holder or firmly held in the hand. Some soothing ointment should be applied to the affected part when there has been a very strong reaction.

Mild or strong doses may be needed: mild doses for localized cases of eczema and trophic conditions, and strong doses for lupus, port-wine stain and keloid, and when a counter-irritant effect is desired, as in cases of sciatica, and also rheumatoid arthritis.

A lamp of the "Kromayer" type is most often employed for local application in the treatment of skin conditions of limited size.

Only areas equal in size to the quartz window of the lamp (*i.e.* 2 in. in diameter) can be treated at once. If only superficial effect is required the lamp is held about four inches from the lesion. For example, in cases of alopecia, exposures varying from five to fifteen minutes are given. If deeper action is necessary the quartz window is applied directly to the skin and pressure maintained to cause exsanguination of the part and so obtain greater penetration of the rays, as otherwise the majority of them are absorbed by the blood in the capillary vessels. This mode of application is used in cases of lupus, nævus, etc., and the length of exposure varies from one to forty-five minutes.

Lighting the "Kromayer" Lamp.—Before lighting the lamp it should be seen that the water is running at the rate of about four pints a minute, and that the

water tubes are correctly fitted to the inlet and outlet tubes on the burner casing. The main current should then be switched on, and then the rheostat switch with the regulating lever at the weak position (reduced).

The burner handle should now be firmly held with

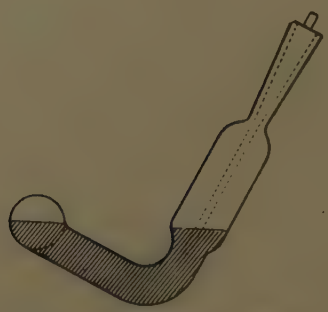


FIG. 122.—Diagram of Method of Lighting the "Kromayer" Lamp. When tilting the Burner to strike the Arc, it should not be tilted too far from the Vertical Plane, or the Electrodes will no longer be in contact with the Mercury.

FIG. 123.—Diagram showing how the "Kromayer" Burner can be tilted too far when lighting it, so that the Mercury is no longer in contact with the Electrodes.

the right hand, while the hand wheel, which is directly beneath the spring clamp holding the burner, is loosened with the left. The burner should now be gently and evenly tilted forwards, to an angle which must never exceed ninety degrees, until the two mercury columns in the parallel limbs of the burner arc tube meet and establish metallic connexion between the two electrode vessels, the current short-circuiting through the mercury. The burner is now brought slowly back to its original vertical position,

causing the mercury column to be broken, and the arc struck.

The hand wheel is then tightened and the lamp allowed to burn two minutes before the regulating

FIGS. 124 and 125.—Method of Lighting the Water-cooled "Uviarc" Lamp. (As can be seen, this differs from the method employed in lighting the "Kromayer" Lamp.)

Showing the Vertical Position in which the lamp is held before it is tilted to strike the arc.

The burner is tilted to the Horizontal Position shown for a few seconds only, and then replaced in the vertical position seen in Fig. 124. After five minutes in the vertical position the lamp is ready for use. The tilting causes the mercury from the cathode to come into contact with the anode and complete an electrical circuit through the tube.

lever is turned on another stud; a minute is then allowed to elapse between each stud, until it is at full strength. With the direct-current lamp the current-direction indicator should always be looked at to see if the polarity is correct. R=right; F=fault. Five minutes after ignition the lamp can be used by removing the mica protection screen.

The alternating-current lamp often needs repeated tilting. When the arc has been struck, and light is

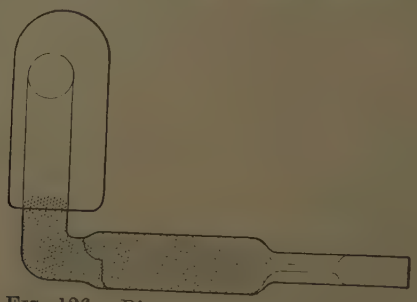


FIG. 126.—Diagram of the "Kromayer" Direct-Current Burner, showing the correct position of the Mercury in the Burner after the Lamp has been burning a few minutes.

seen, the transformer button should be pushed down, the lamp being kept in an inclined position for a

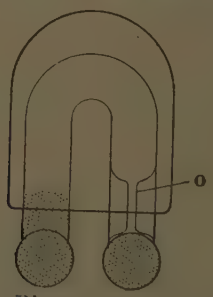


FIG. 127.—Diagram of the "Kromayer" Burner (D.C. Type), showing the correct levels of the Mercury after the Lamp has been lighted for four to five minutes. If there is much mercury in the right-hand limb above the constriction, O, the lamp should be extinguished and relighted.

further half-minute, and then brought slowly back to the upright position.

FIG. 128.—Applicators and Holders for use with the "Kromayer" Lamp.

Only very slight deviations from the vertical plane are permissible with the "Kromayer" lamp.

Watchfulness must be shown to ensure that an efficient water circulation is being maintained—sudden withdrawals of water from neighbouring taps are the commonest cause of trouble.

When the treatment is finished, first turn off the

FIG. 129.—Water-cooled Quartz Compressor for use with the "Finsen" or "Finsen-Reyn" Lamps. (Sanitas, Berlin.)

current and then the water. It is advisable not to allow the water to flow away, but to keep it in the lamp until the quartz has gradually cooled, to prevent cracking. The metal jacket of the water-cooled burner should never be allowed to get too hot—it should always be possible to hold it comfortably in the hand.

Applicators and Compressors.—Solid quartz applicators can be obtained, of different shapes or sizes, which can be fixed to the quartz window of the lamp in order to treat parts, such as the nose, where, owing to irregularities in contour, it is difficult to apply the window directly.

For the treatment of orifices, solid quartz rods may also be used, or hollow cone-shaped applicators of

quartz, fitted with water-cooling devices, may be obtained for irradiation of the vagina, rectum, mouth, etc.

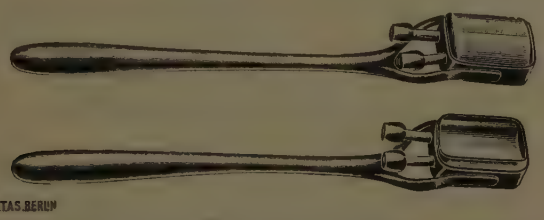


FIG. 130.—Quartz Compressors for use in Tubercular Dactylitis in association with the "Finsen" or "Finsen-Reyn" Lamps.

FIG. 131.—Different types of Quartz Compression Apparatus for use with the "Finsen" or "Finsen-Reyn" Lamps. (Sanitas, Berlin.)

When these applicators are used very little ray intensity is lost by the increase in distance between the burner and the part under treatment, as quartz conducts the

rays much more easily than air, and the law of inverse squares is not applicable to this substance.

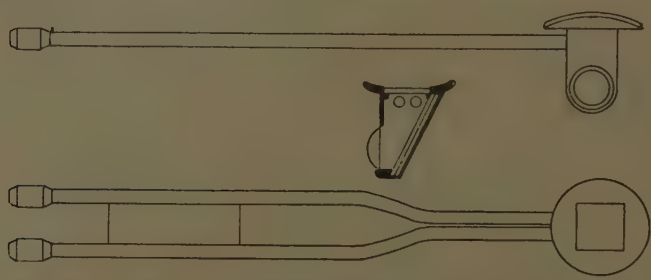


FIG. 132.—Prismatic Quartz Applicators used with the "Finsen" or "Finsen-Reyn" Lamps, principally for the Treatment of Lupus affecting the Mucous Membrane of the Nose. The Small Diagram shows where the Radiation leaves the Applicator. (Reyn.)

The Finsen Institute compressors are separate, and are not attached to the lamp itself, but are held in position by a nurse. An independent water supply

FIG. 133.—Large Square Applicator for Compression of Skin Lesions, for use with the "Kromayer" Lamp.

FIG. 134.—Small Round Dermatological Compression Applicator for use with the "Kromayer" Lamp.

circulates through them to keep them cool. The one most commonly used consists of a plate of rock quartz, and a plano-convex lens separated by an enclosed space, 5 mm. in thickness, through which the water circulates.

There is also an oval-shaped Finsen compressor, and one with a concave lens specially designed for use in tubercular dactylitis.

Prismatic applicators are used for treating lupus of the nose.

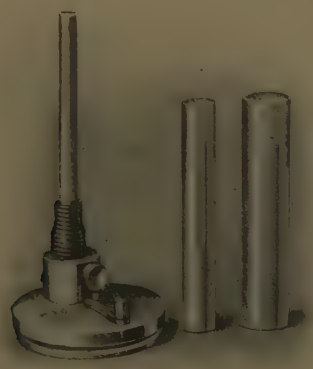


FIG. 135.—Dr Cemach's Quartz Applicators, principally used for Nasal Treatment. A Spiral Spring makes the Rod flexible and less liable to be broken. With this Applicator the Rays can be used without filtration or they can be passed through blue Uviol Glass.

A large range of useful applicators can be employed with the "Kromayer" lamp.

We use two or three plano-convex lenses of different size for dermatological work, and find the Cemach spring applicator invaluable for nasal work.

There are other special applicators which will be needed for treating the mouth, urethra, posterior nares, etc.

A large number of hollow metal specula have been designed for localizing the rays; these are, of course,

of no use in compression work. They are most often used for treating the vagina, rectum, ear, nose and mouth.

The authors have evolved an applicator of the speculum type, which can be used for the simultaneous irradiation of both nostrils, in such conditions as ozæna, nasal catarrh, etc., and can be used with either

FIG. 136. — Our Nasal Speculum, manufactured by Kelvin, Bottomley & Baird, can be used if desired for the simultaneous Irradiation of both Nostrils. The Nozzles are mounted on a rubber base and readily adapt themselves to the Nostrils. The rubber also prevents the nozzles from becoming hot through heat conduction.

their own type of housing for the air-cooled lamp or with the "Kromayer" lamp.

Gallois et Cie have recently introduced some quartz high-frequency electrodes similar to those of McIntyre, which can be used for cavity work, and which give off an appreciable amount of ultra-violet rays.

Fused quartz applicators can be sterilized by simply passing them through the naked Bunsen or spirit flame, but natural quartz crystal must never even be boiled, and can be sterilized by soaking in a 1 : 1000 solution of corrosive sublimate.

Blue Filters.—Professor Kromayer has devised a method of cutting off the superfluous heat and non-penetrating short-waved ultra-violet rays by interposing screens of varying thicknesses of blue Uviol glass with a perforated metal holder between the quartz window and the cover of the burner, that is actually in the water bath itself. In this way the blue, violet and long-waved ultra-violet rays are allowed to pass through the screen, while the red and heat rays and the ultra-violet rays of short wave-length are absorbed. The amount of absorption varies with the thickness of the glass screens.

The quartz window of the lamp can be replaced also by a blue Uviol glass filter, but this can be made only a certain thickness, or else the surface which is not in contact with the circulating water may become too hot.

Dosage with the "Kromayer" Lamp.—Third or fourth degree reactions are usually required.

The "Kromayer" lamp produces:

A first-degree erythema with contact in 10 seconds.
A second-degree erythema with contact in 25 seconds.
A third-degree erythema with contact in 40 seconds.
A fourth-degree erythema with contact in 1 minute.

Compression for a minute with a quartz rod will generally produce a blister.

At four inches distance from the skin:

1 minute's exposure generally produces a first-degree or second-degree erythema.
2 minutes' exposure generally produces a third-degree erythema.
3 minutes' exposure generally produces a fourth-degree erythema.

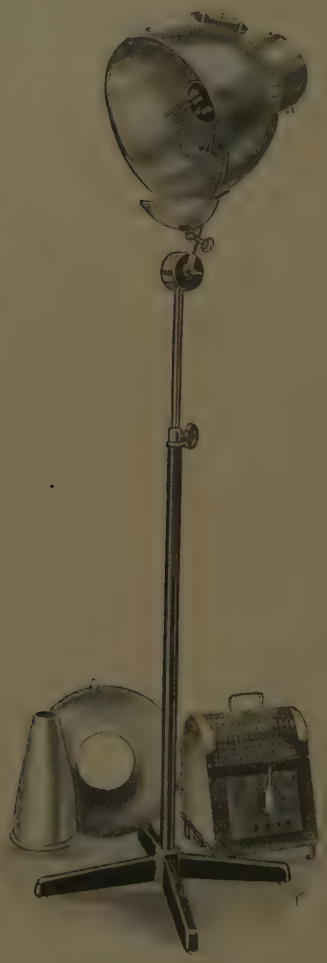


FIG. 137.—The "Solart" Carbon Arc Lamp, 100 to 250 volts, D.C. or A.C., automatically regulated, taking about 9 ampères.

Doctors are often diffident about giving the necessary doses with the "Kromayer" lamp, but there is practically no difference in the discomfort produced by a blister following three minutes' exposure at four inches distance and one caused by half-an-hour's exposure at the same distance; and more benefit will naturally result from the longer exposure, as the rays have had so much more time to act on the tissues.

There is, however, a great difference in the effect of a blister produced by compression and one caused by a long exposure at a distance of, say, three feet, as in the latter case the air filters out the rays of short-wave length.

Treatment with the "Kromayer" lamp is usually applied to an area every seven to fourteen days—that is, when the previous reaction has quite subsided.

The Carbon Arc Lamp.—Arc lamps with pure carbons are used at the Finsen Institute, Copenhagen, and Dr Reyn prefers them to impregnated carbons, because he considers that, though impregnated carbons give off more ultra-violet rays of short-wave length, there is less penetration, and they also produce pungent fumes.

The general tendency, however, especially in this country, is to use impregnated carbons.

Some workers use plain carbons for the first applications, and replace them by tungsten-cored carbons later in the course of treatment.

Dosage for Carbon Arc Light Baths (Short-Flame Arcs) at the Finsen Institute.—Always at the same distance commence with 15 to 20 minutes' exposure to

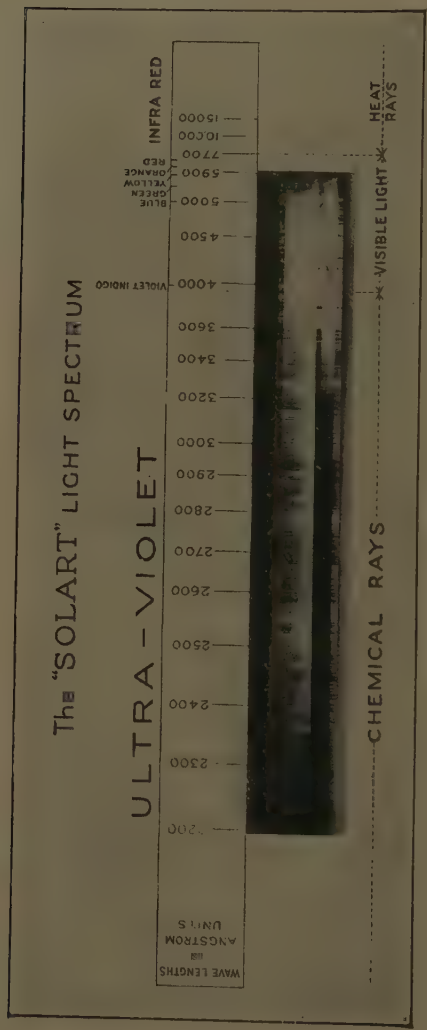

The "SOLART" LIGHT SPECTRUM
ULTRA-VIOLET
WAVE LENGTHS IN ANGSTROM UNITS
2200
2300
2400
2500
2600
2700
2800
2900
3000
3200
3400
3600
4000
4500
5000
5900
7700
10000
15000
VIOLET INDIGO
BLUE GREEN YELLOW ORANGE RED
INFRA RED
CHEMICAL RAYS
VISIBLE LIGHT
HEAT RAYS

Fig. 138.

each side of the body, as near the lamp as possible; increase this by 5 to $7\frac{1}{2}$ minutes at each application, until a maximum of 75 minutes is reached:

1st application,	15 to 20	minutes	to each	side	of body
2nd ,,	20 to $27\frac{1}{2}$	,,	,,	,,	
3rd ,,	25 to 35	,,	,,	,,	

Patients with laryngeal or pulmonary tuberculosis: first application, $7\frac{1}{2}$ to 10 minutes to each side of body. Each exposure is increased by $2\frac{1}{2}$ to 5 minutes, until a total of one hour to each side of the body is reached.

Patients with heart or lung disease are placed at a greater distance from the lamps: first application, $7\frac{1}{2}$ to 10 minutes to each side of body, increased at each application by $2\frac{1}{2}$ to 5 minutes, until 75 minutes' exposure of each side of the body is attained.

Skin Diseases.—First exposure, $7\frac{1}{2}$ to 10 minutes—length of each application increased by $2\frac{1}{2}$ minutes, up to a maximum of 75 minutes to each side of the body.

The first application to infants should be 5 minutes, and increased by $2\frac{1}{2}$ minutes at each treatment, till the maximum of 75 minutes to each side of the body is reached.

Long-Flame Arc Dosage:

First application, 10 minutes to each side of body, as near the arc as possible.

Second application, 15 minutes to each side of body, as near the arc as possible.

Third application, 20 minutes to each side of body, as near the arc as possible.

Treatment preferably given every other day.

"*Arnold*" *Arc Lamp.*—5 to $7\frac{1}{2}$ minutes to each side of body, at three feet from the lamp, increasing to 15 to 20 minutes as near the arcs as the heat allows.

Ajax and Saidman Polymetallic Arcs:

First exposure, 5 minutes to each side of body, as near the arc as possible.
Second exposure, 7 minutes to each side of body, as near the arc as possible.
Third exposure, 9 minutes to each side of body, as near the arc as possible.
Fourth exposure, 11 minutes to each side of body, as near the arc as possible.
Fifth exposure, 13 minutes to each side of body, as near the arc as possible.
Sixth exposure, 15 minutes to each side of body, as near the arc as possible.

With children, in whom it is difficult to judge sensitivity to heat, the following data may be of value:

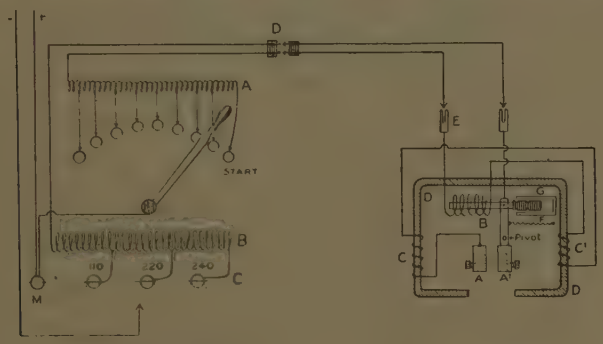
With the 4-ampère arc the child should be placed 25 cm. away.
With the 8-ampère arc the child should be placed 30 cm. away.
With the 12-ampère arc the child should be placed 35 cm. away.
With the 18-ampère arc the child should be placed 40 cm. away.

When the 4-ampère portable arc is being used the dosage given in the Table should be doubled.

From these Tables it will be seen that with the carbon arc there is not nearly so big a difference between the length of the first and last applications as there is in the case of the mercury vapour lamp.

When the whole body has to be exposed it is of great advantage to have two lamps in series, so that the front and back of the patients may be treated simultaneously, thus saving much time.

Short-flame arcs consuming 20 ampères are sufficient in general practice, and two patients can be



DISTRIBUTING BOARD

A. Resistance for fine adjusting of current.
B. Resistance for selecting voltage.
C. Terminals for connecting to mains.
D. Plug and socket for connecting to lamp.

BURNER

A.A' Carbon carriers.
B. Solenoid with plunger.
C.C' Solenoids.
D. Electro-magnet.
E. Terminals.
F. Spring to strike the arc.
G. Dash pot.

FIG. 139.—Diagram of the Mechanism of the "Solart" Carbon Arc Lamp.

treated together. When one patient only is being treated, reflectors can be placed behind the arcs to increase the intensity of the radiation.

Perspiration is so profuse during carbon arc treatment that it is generally essential to have a tepid shower afterwards. In hospital practice it may be wise in certain cases for some of the patients to have a sponge-down before treatment also, so that the radiation can exert its maximum effect.

Trimming an Arc Lamp.—A pair of tongs and a spanner are useful for trimming an arc lamp; the old carbons must be removed and the carbon-holders thoroughly cleaned with a dry rag. The lamp mechanism must never be oiled, as the lubricant would coagulate with the heat. In a lamp where the carbons are in the vertical plane they should be adjusted so that they are exactly co-axial. The carbons must not be screwed into the holders too tightly or they will be crushed and will probably break. At the same time they must be fixed securely or the carbons may become loose and fall out of their holders. We have known both these accidents to happen. A stout wooden stick is useful for correcting the position of the carbons.

At the Finsen Institute they clean the regulating mechanism of their lamps with a small hand air-pump, and find this an easy way of removing dust.

The distance from the Finsen short-flame arc to the patient is so carefully measured that it should be seen that the positive and negative carbons are burning at the same rate, and that the arc maintains the same level.

When several arcs are burning in series, as in the "Arnold" lamp, if the arc between one pair of carbons is interrupted all are extinguished; the current should then be turned off and the carbons adjusted with a pair of tongs and a screwdriver, so that they will come evenly into contact; the lamp can then be relit.

Hissing.—Direct-current arcs generally become unstable when the current to them is raised above a certain figure. Instability is recognized when hissing

FIG. 140.—"Sunic" Parallel Carbon Arc Lamp (for Local or General Treatment), fitted with Localizer.

occurs; the noise is caused by free access of air to the greatly enlarged crater which has overspread the end of the positive carbon. The voltage across the arc falls suddenly when hissing begins, but increases

FIG. 141.—Belot's Method of mounting four Carbon Arcs in Series.

if the arc is lengthened, provided that the current is kept at a constant level.

With the carbon arc a mushroom-shaped excrescence often forms on the tip of the negative carbon. This white-hot fragment eventually becomes detached; care must be taken to prevent these falling fragments from igniting any inflammable material on

the treatment-room floor. They are most easily caught in flat tin dishes or on asbestos trays.

The Tungsten Arc Lamp.—Any simple hand-feed arc lamp will suffice, though the usual practice is to have the tungsten electrodes in the horizontal co-axial position. If the positive electrode is tungsten,

FIG. 142.—A Portable Tungsten Arc Lamp.

a tungsten-cored carbon will be sufficient for the negative electrode. The tungsten arc lamp can be run only off the direct current. A rotary converter must be used if the supply is alternating. A variable resistance from zero to 15 ampères is an advantage.

A reflector, made of a material which absorbs as few of the rays as possible, should be fitted behind the arc.

Silicon is the most useful metal for this purpose,

as it reflects 75 per cent. of ultra-violet rays. Nickel reflects 45 per cent., while silver reflects only 6 per cent. In some cases where local lesions are being treated a concave mirror may be substituted to focus the rays on the part, and again, the reflecting surface should be coated with nickel or silicon. More often the rays are focused by means of a quartz lens two inches in diameter and having a focal length of four inches. This is held in a circular frame which should be of sufficient size to protect the area surrounding the part under treatment. A long handle is fitted to the frame. A splutter bowl is placed usually under the electrodes to catch any falling fragment.

It must be remembered that the ultra-violet rays come to a focus at a point which is nearer to the arc than the focal point of the visible rays. This can easily be proved with an oxide-of-nickel filter and a piece of uranium glass. The reflection method is considered the most satisfactory, because even quartz absorbs a certain amount of the radiation which passes through it.

With the ammeter registering 10 ampères, and the rays focused on the part by means of a quartz lens, five minutes is generally about the time necessary to cause the required erythema. But again all the other factors which influence dosage should be taken into account. When the erythema is fading the dose is repeated.

We have had experience with the molybdeno-tungsten arc lamp, which is an arc lamp in which the larger positive electrode is of carbon cored with tungsten, and the smaller negative electrode is of

carbon only. The falling red-hot pieces of tungsten are caught in a quartz globe. The lamp is used mainly for local lesions, and is especially effective in superficial tubercular lesions, such as dermatitis, abscesses,

FIG. 143.—The Molybdeno-Tungsten Arc Lamp.

lupus, etc. The lamp is held as close to the lesion as possible for from two to five minutes daily, care being taken to protect the surrounding healthy skin as described before.

One disadvantage of the molybdeno-tungsten lamp

carbons is that, being directed vertically downwards, beads of red-hot tungsten often fall out of the encircling carbon sheath. This is often a source of alarm to the patient.

Combined Treatment.—In certain cases the effect of ultra-violet radiation may be enhanced by using it in conjunction with other forms of electrical treatment, such as with infra-red rays or with ordinary carbon filament lamps, usually fitted to encircle the ultra-violet radiation lamp. We were led to use ultra-violet rays conjointly with other methods of electrical treatment in those cases in which the same physiological effect could be achieved by the two different types of application. Examples of this were found in the treatment of chilblains, in which the alternate use of ultra-violet radiation and Schnee sinusoidal baths were found to be very advantageous. Likewise, when a tonic effect was desired, high frequency or diathermy with the auto-condensation couch was administered alternately with ultra-violet radiation, with considerable benefit. The same combination was also used in cases of hyperpiesis, diathermy and ultra-violet radiation, both lowering high blood pressure.

Some varicose ulcers seem to respond better to treatment when zinc ionization is given in conjunction with the ultra-violet rays, and we have had successful results in several cases.

Certain local skin affections yield satisfactorily to combined ultra-violet radiation and high-frequency discharges from glass electrodes.

Another successful combination is that of X-rays and ultra-violet radiation.

Sampson advises an ionizing dose of X-rays, one milliampère for five minutes at a distance of eight inches between the anti-cathode and the skin, with a five-inch spark gap and a one-millimetre aluminium filter. Three applications can be given at intervals of three to seven days.

We have used this technique ourselves with success.

Ultra-violet radiotherapy and heliotherapy can, of course, be combined, and this is the usual practice at many places in this country.

Remedies for Faults.—Occasionally it is difficult to get ultra-violet lamps to work properly. A short description of a few of the commoner causes of trouble may be useful.

The lamp may go out suddenly during a treatment. This may be due to several causes, one very common cause being some interruption in the current. This may be due to a cutting off of the main supply, either unexpectedly through failure at the power-house, or purposely to permit of repairs being carried out in the neighbourhood. The other sources of supply should therefore be immediately tested. If they are off, too, inquiry should be made to see if adjacent premises are also without current. If the trouble is limited to the one house only, the main fuse will probably be found to be blown.

When only one source of supply is affected the branch fuse should be examined. If the trouble is confined to one plug and its near connexions a simple test-lamp is of great help in localizing the defect, as the plug, flex and terminals can all be tested without difficulty, and it can soon be seen whether they are in

order. The test-lamp will light up only when current is passing. The flex wire connexions in the plug can easily become broken. The flex cord itself may be defective, either from a partial break in the conducting core or from imperfect insulation. Defects should always first be looked for at the most vulnerable point —viz. the junction of the fixed and movable parts. The terminals should be examined to see if they are clean and also properly connected.

With the hanging type of mercury vapour lamp it is advisable to see that the alignment of the lamp is correct, because if it is not the lamp may go out. If the polarity of the terminals has been reversed the lamp will burn for a time and then become extinguished, owing to destruction of one of the electrodes.

If the vacuum of the burner is impaired the arc tube becomes discoloured, and black and yellow patches appear. The leakage can be confirmed if the burner is taken out of its housing and moved sharply sideways. If the vacuum is defective the characteristic click is not obtained.

If a lamp goes out during operation it should be allowed to cool thoroughly before an attempt is made to relight it; this is usually due to overheating through the hood having been closed.

It can generally be said that if a lamp has been burning satisfactorily for some time, and then goes out suddenly, the fault should not be looked for in the burner, but in the circuit.

The authors have noticed once or twice that their mercury vapour lamps have gone out when they

have switched on a large arc lamp in an adjacent room.

There are several causes of trouble which may arise with the water-cooled mercury vapour lamp. Briefly, these are as follows.

Defective water circulation is the commonest fault, allowing the lamp to become overheated; one way in which this may be brought about is by interchange of the inlet and outlet tubes; another is by cracking of the quartz jacket of the arc tube; interchange of positive and negative poles will also cause the lamp to burn permanently dull.

If the lamp burns only after frequent tilting it is probably because a small air bubble which is usually present in the polar vessels has found its way into the arc tube. This can be remedied by gently tilting the lamp forward to an angle of ninety degrees to its original plane and then bringing it gently backwards again. If the lamp should become accidentally extinguished, two minutes should be allowed to elapse before an attempt to relight the lamp is made; at the same time the resistance should be immediately moved to "weak." When a leakage of water occurs at the quartz window of the lamp a new rubber packing ring should be fitted.

If the water used for cooling the lamp contains a great deal of lime the inside of the burner casing should occasionally be cleaned—it may be necessary to use a five-per-cent. solution of hydrochloric acid to do this efficiently.

In the case of carbon or tungsten arc lamps, the carbons should first be touching and then should be

quickly separated to the required distance, when the arc has been struck. A supply of suitable fuse wire, of varying thicknesses, should always be kept in an easily accessible place in case of emergency. So also should a candle and matches, or a small flash-lamp —one of the self-generating type is very handy, as refill cells are not required. Too thick fuse wire for a particular fuse should never be used, as, after all, a fuse is a safety device and a means of avoiding more serious consequences. Great care should be taken to prevent unauthorized persons from having access to the ultra-violet lamps. A little curiosity may cause great trouble and damage.

An Outline of Conjoint Internal Medication and Ultra-Violet Radiation

Organic Preparations:

Thyroid extract.
Ovarian extract.
Testicular extract.
Vaccines (such as tuberculins).
Cod-liver oil (in rickets).
Chlorophyll.
Stercoporphyrin } sensitizers.
Uroporphyrin }

Inorganic Preparations:

Calcium chloride { intravenous in abdominal tuberculosis.
Colloidal calcium.
Arsenic (in tuberculosis).
Gold preparations { in lupus, lupus erythematosus, laryngeal and pulmonary tuberculosis.

Iódine.
Eosin (1:1000)
Erythrosin } sensitizers.
Gentian violet (1:1000)

Ostermann finds that very small quantities of the heavy metals circulating in the blood increase the effect of the ultra-violet rays:

Iron, in anæmia.
Mercury, in syphilis.
Bismuth.
Copper, in surgical tuberculosis.
Silver, argochrome (silver and methylene blue), used intravenously in influenza and pneumonia.
Gold, in laryngeal tuberculosis and septic processes.

Reactions in Local Treatment are increased by the external application of the following:

Copper ointment, in lupus
Silver nitrate.
Hydrogen peroxide.
Calcium sulphide powdered on the skin.
Sodium chloride.

And by these dyes:

Eosin.
Brilliant green.
Crystal violet.
Gentian violet.
Fluorescin.
Cyanosin.

CHAPTER X

SKIN DISEASES

Outline of the Biological Effects of Ultra-Violet Radiation—Mode of Action in Varying Conditions—Effect in Skin Diseases—Treatment of Skin Conditions accompanied by Anomalies of Sensation—Inflammatory Lesions of the Skin—Inflammations of the Surface Epidermis—Of the Deep Epidermis—Local Infective Inflammations of the Corium—New Growths—Nævi—Ulcers—Anomalies of Pigmentation—A few Illustrative Cases

It is foolish to suggest that ultra-violet radiation, or for that matter any other remedial agent, is a "cure-all."

But it is equally absurd to criticize the favourable results, which different workers have claimed after actinic treatment, in so many diverse conditions.

Are most diseases not benefited by the stimulation of the defensive mechanisms of the body ?

The argument that these results are due entirely to suggestion is hardly worth discussing.

The greatest field of usefulness for ultra-violet radiation lies in the prevention rather than the cure of disease.

Ultra-violet radiotherapy, however, is almost a specific remedy in such dissimilar conditions as rickets, surgical tuberculosis, alopecia areata, spasmophilia and hay fever.

In a very large number of diseases it is a useful

adjuvant, supplementing other necessary remedial measures.

When selecting cases for ultra-violet radiation the biological effects of the rays must be borne in mind. It must be remembered that the rays form some substance in the skin which is absorbed by the blood, and thus carried throughout the whole of the system. The chief general effect is an increase in the rate of metabolism, the appetite is stimulated, and the whole resistance of the body is raised; hence the value of this treatment after acute illnesses and in weakly children and adults. The number of micro-organisms in the intestinal tract is reduced, absorption is facilitated and catarrh is lessened. The tone of unstriped muscle is increased, and obstinate cases of constipation and auto-intoxication from the bowel are greatly benefited. Anæmias are aided by stimulation of the hæmopoietic system, and increase in hæmoglobin; rickets from the increase of calcium and phosphorus in the blood; and surgical tuberculosis and many infections by the increase of the bactericidal power of the blood, lymphocytosis, and increase of general resistance. Ultra-violet radiation also stimulates the endocrine system, especially the thyroid and sexual glands.

Similarly many other conditions can be thought of which might be benefited by ultra-violet radiation when one considers its physiological properties.

The benefits derived from ultra-violet treatment may be due to:

(1) Psychical effects attributable to:
Suggestion or mental exhilaration.

(2) Alterative effects:
Stimulation of Carbohydrate,
Protein,
Fat,
and
Mineral metabolism { Calcium. Iron. Phosphorus. Iodine.
Production of vitamin D from cholesterol.
Stimulation of the sympathetic system and endocrine glands.
Increase of hæmobactericidal and immunizing powers.
Lowering of abnormally high blood pressures.

(3) The production of a beneficial inflammation, as in indolent ulcers.

(4) A local counter-irritant effect, as in certain cases of neuritis.

(5) Direct bactericidal effect.

(6) Analgesic effect.

(7) Stimulation of vasomotor reflexes of the skin, lessening the susceptibility of the body to extremes of heat or cold.

(8) Redistribution of the amount of blood in the different circulatory systems—for example, a lessening of the amount of blood in the portal circulation.

Illustrative cases of a few of the conditions mentioned will be given.

The great value of ultra-violet radiation in dermatology is due to its bactericidal effect, to its stimulating action on cellular growth and, indirectly, to the raising of the resistance of the whole body to

infection. Improved cellular nutrition, the formation of keratin and pigmentation also play important parts.

The physiological functions of the skin are stimulated by exposure to radiant energy, and cool moving air.

Captain Braithwaite, of the West African Medical Service, informs us that eczema, impetigo, furunculosis, lupus and psoriasis are unknown among the Nigerian negroes, and that extensive wounds heal rapidly without sepsis; and, as already noted, Dr Leuba, of the Swiss army, found that pigmented skins would not respond to vaccination until the skin had actually been cut through, instead of the usual scarification.

As a rule, acute conditions require sedative dosage, while heavy, and often blistering, doses are necessary for the cure of chronic forms of disease.

In conditions where there is marked induration occasional applications of Röntgen rays, as well as the ultra-violet radiation, often hastens recovery. Some workers also combine high-frequency sparks. The sedative effect of ultra-violet energy on the nerve endings in the skin is invaluable in those conditions which are associated with the intense itching which is such a distressing symptom of so many dermatoses. Often the first exposure relieves this symptom, which is so much more difficult to endure than actual pain.

Diseases of the Skin accompanied by Anomalies of Sensation

Pruritus (*General, Anal and Vulval*).—This condition, if severe, can become intolerable, causing grave discomfort and insomnia. Medicinal treatment

is usually inefficacious. The first thing to be done in treating this affection is obviously to discover any ascertainable cause. Oxyuris vermicularis, pediculus capitis and pubis, and acarus scabiei should all be looked for; the urine should also be tested for the presence of bile, sugar or albumin.

In *Pruritus ani*, hæmorrhoids, fissure, anal catarrh and small sinuses should all be sought; and, in *Pruritus vulvæ*, vaginitis. If possible, the cause should be removed. If none of these sources can be found, especially if the pruritus is paroxsymal, the condition is almost certain to be essential or true pruritus. Ultra-violet radiation is very useful in these cases, the analgesic effect being very quickly felt.

General Pruritus is treated by mild doses to the whole body, preferably given thrice weekly, and gradually increased.

Local Pruritus, Anal.—Before commencing ultra-violet treatment all hairs should be removed and the parts well washed with soap and water and thoroughly dried. We have used both the air-cooled and water-cooled lamps in these cases; the patient can bend down with the buttocks facing the lamp, and he can himself pull apart the cheeks of the buttocks, with his hands protected by black cotton gloves, so as to smooth out any folds which may exist; or the patient may adopt the knee-elbow position and have the cheeks of the buttocks separated with our special retractor.

All parts which have not to be exposed must be suitably protected, or a tubular diaphragm may be

used. A quartz compressor can conveniently be used with the water-cooled lamp, and erythema doses given two or three times a week.

With *Pruritus vulvæ* the lithotomy position is most convenient. If there is any vaginitis it should be treated by diathermy, or by Dr Sloan's method of ionization.

Relief is afforded by the radiation, owing to the analgesic effect of the rays on the interepithelial nerve fibrils, and also to the powerful bactericidal effect of the radiation. The condition can usually be cured with from six to twelve applications. Small perineal abscesses and sinuses which may be present are also benefited and cured.

Inflammatory Lesions of Skin

Dermatitis due to Physical Causes: X-Ray Dermatitis.—X-ray burns and dermatitis are greatly benefited by ultra-violet radiation, and for these conditions this method of treatment is considered superior to any other. Intensive irradiation is necessary to bring about regenerative changes in the open ulcer, and to remove keratoses. The water-cooled lamp is most useful, and should be used with compression. All sloughs and dead skin should be removed before treatment. Two or three exposures of ten to fifteen minutes with the "Kromayer" lamp, using compression, should be given, at intervals of three or four days, so that an intense reaction is caused. After this procedure lighter reactions with the air-cooled lamp are advisable.

If the condition is simply a dermatitis, and not severe, mild erythema doses given thrice weekly are all that is required to stimulate regeneration without destroying newly formed epithelium.

Dr Sampson has done a great deal of work on this subject, and he exposes the lesions to radiant heat before applying ultra-violet rays. Hagen has reported eight cases of "radiodermatitis" which have been cured in fifteen to thirty minutes by two applications of the "Kromayer" lamp. The telangiectases also disappeared.

In old X-ray burns, which threaten to become malignant, ultra-violet radiation is strongly advised, and many successful cases are reported.

Burns and Scalds—however they may be caused (thermal, electrical or chemical)—respond well. Regeneration of the destroyed epithelium is promoted by mild doses. The newly formed epithelium should be carefully covered during the exposure of the wound, as the rays might easily damage these new cells. The rays have a bactericidal action, and also stimulate new cell formation.

Irradiation should be given thrice weekly, beginning with a dose of one and a half minutes at thirty-six inches, and very gradually increasing the exposure and decreasing the distance until five minutes at eighteen inches are being given.

Sterile gauze or picric-acid dressings should be applied after irradiation. The application of ointments, which are opaque and difficult to remove, should always be avoided.

Sometimes it may be advantageous to use a blue

Uviol filter, so as to absorb the short abiotic rays, which may destroy the new epithelium.

Dermatitis venenata.—This condition responds readily to ultra-violet radiation, especially when it is due to the poison ivy. The burning and stinging which are associated with the condition are usually dispelled by the first or second exposure, and spread is also prevented if the skin for an area of several inches round the original lesion is rayed.

A second-degree erythema should be given with either the "Kromayer" or the air-cooled lamp—if the lesion is of any size the last named is preferable. Exposures should be given every other day until the condition has cleared up.

We successfully treated several cases of acute dermatitis caused by the dye from fur collars—the intense irritation was relieved after the second or third exposure to the rays.

Bakers' rash and grocers' itch are other examples of this condition which respond well to ultra-violet irradiation. We have recently been able to cure an old-standing case of baker's dermatitis.

Eczema.—Ultra-violet radiation proves a very valuable therapeutic agent in this common condition, especially in its subacute and chronic forms.

In very acute types, associated with profuse exudation and œdema, ultra-violet radiation is contra-indicated. In less severe forms mild sedative doses are beneficial. All discharge or crusts should be removed before irradiation. Starch poultices may be useful in this connexion.

The subacute forms which are so often associated

with bacterial (staphylococcal and streptococcal) infection respond most readily to this treatment, on account of the bactericidal action of the rays, associated with the increased blood supply to the part, and the stimulation of epithelial growth.

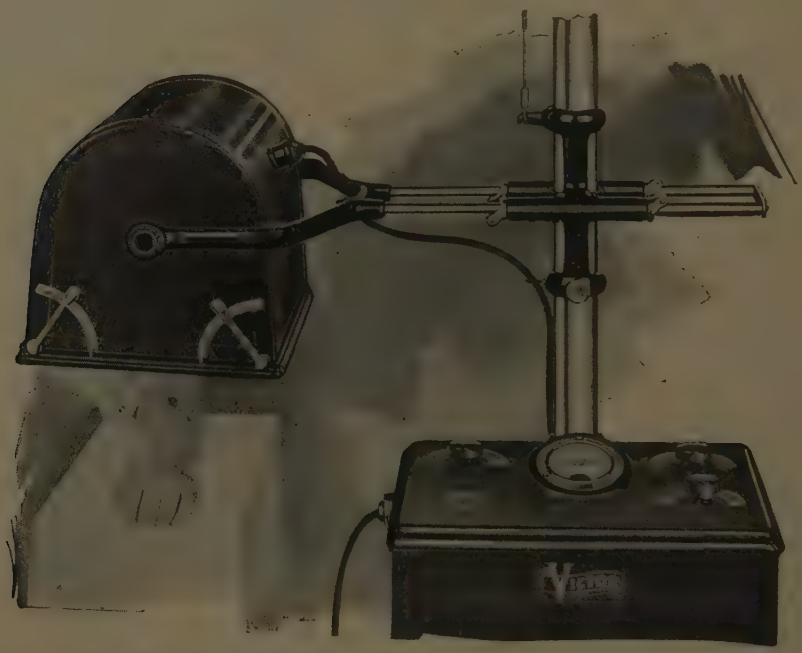


FIG. 144.—The "Uviarc" Air-cooled Mercury Vapour Lamp being used for the Treatment of a Skin Lesion of the Forearm.

The eczemas of childhood and infancy are generally of this type, and respond well to irradiation.

A second-degree erythema, repeated two or three times weekly, is advised. General irradiation, in addition to local treatment, is often advisable, as it raises the general resistance of the body.

The chronic forms are more resistant to treatment,

and need more drastic measures. Third-degree erythema should be produced, and if progress is slow—and especially in the infiltrated, scaly, lichenoid types—X-rays should be used in conjunction with ultra-violet rays.

Lomholt advocates the use of the "Finsen" lamp in cases of chronic eczema, especially in dry, infiltrated lesions, and has found it useful in many vesicular cases also. He reports 60 per cent. of his cases of chronic eczema cured, and 25 per cent. improved, and he advises an average exposure of fifteen minutes.

Saidman obtains good results in resistant cases by the combined use of ultra-violet rays, X-rays and the high-frequency spark discharge.

We have had good results in eczema intertrigo by combining actinotherapy and X-rays.

Seborrhœic dermatitis—especially of the scalp—responds with remarkable rapidity to ultra-violet radiation.

Nagelschmidt has always found a few applications sufficient to cure *Seborrhœa capitis*. He mentions fifty-three cases of alopecia of a seborrhœic type which were all cured, generally after one application. He gives four tests of cure:

(1) The disappearance of subjective discomforts—tickling, itching, etc.
(2) The cessation of the formation of scurf.
(3) Regrowth of lost hair.
(4) An increase in the length of the original growth or of the total growth.

The scalp should be washed the day before irradiation. A stimulative third-degree erythema is necessary

for each portion of the scalp, which should be carefully divided into furrows about half-an-inch apart, radiating from the crown; non-inflammable combs should be used for this purpose.

Another application is given when the reaction from the previous one has subsided. If every six months three or four treatments are given, at intervals of about twenty-one days, the scalp will be kept in a normal condition.

Seborrhœa corporis is even more satisfactorily treated by ultra-violet radiation; it can generally be cured rapidly. The "Kromayer" lamp should be used for any infiltrated areas.

Erythema pernio.—As could be expected, ultra-violet radiation is particularly useful in this condition, owing to the stimulating effect which the radiation has on the peripheral circulation. The increase of calcium in the blood probably contributes to this improvement also. A third-degree erythema is produced. General irradiation is of more value than local. If the condition is present in the fingers and toes only, Schnee sinusoidal baths given in conjunction with the radiation are very efficacious. It is customary to give fifteen to twenty minutes' bath treatment before the radiation. When the ears and nose are affected, ultra-violet treatment alone, or in conjunction with the high-frequency discharge of vacuum electrodes, is indicated.

People subject to this condition should undergo treatment with the onset of cold weather and continue with intermittent short courses until the spring. Calcium lactate may be given by the mouth during general treatment.

Herpes (*facialis, genitalis and zoster*).—Ultra-violet radiation is rightly considered the best method of treatment for this condition.

The duration of the illness is considerably shortened, and the scarring and pain reduced to a minimum. If the condition is seen before definite development of the vesicles, the water-cooled lamp should be applied to each lesion, the quartz compressor being used. The vesicles in these cases will not develop, and the whole condition will be aborted. If the eruption is well developed and covers a large area, the air-cooled lamp is of more use. A second-degree erythema should be produced.

The pain of the herpes will be greatly relieved after the first application. The vesicles will dry up and fall off, leaving very little scarring, and the whole condition, even when severe, will clear up in a fortnight. No neuralgic pains remain after the disappearance of the vesicles, as is so often the case in cases of herpes in old people who have been treated only medicinally, when the condition often proves most refractive.

Neuralgia following a previous attack of herpes is greatly aided by irradiation producing a second-degree erythema with the air-cooled lamp, and the whole general condition of the patient is improved.

Urticaria.—The intolerable itching which is the most distressing feature of chronic urticaria can soon be relieved by the application of ultra-violet rays. A second-degree erythema with the air-cooled lamp applied generally is usually most satisfactory. We have often found that one application is sufficient to banish the itching.

Anaphylaxis, which is the probable cause of urticaria, is always associated with a decrease in the blood calcium. For this reason calcium lactate should be taken orally.

At least twelve exposures should be given, beginning with two and a half minutes at thirty-six inches to both surfaces of the body, and gradually increasing to ten minutes at twelve inches.

Inflammations of the Surface Epidermis

Impetigo contagiosa.—The "Kromayer" lamp is often advised for this condition, but equally good results may be obtained by the use of the air-cooled mercury vapour lamp.

Local treatment should be given and a third-degree erythema is necessary, both for the bactericidal effect and for the increase of blood and lymph to the part which it causes. All crusts and discharge must be removed. The application of oil or starch poultices may be necessary to accomplish this before irradiation. A smart reaction is required, and the exposure is repeated when the first reaction is beginning to fade (the second or third day, according to the severity of the reaction). The first application prevents the lesions from spreading, and if the condition is not too far advanced three or four applications will prove sufficient to cure the disease, but the treatment should not be discontinued too soon or a relapse may occur.

Pityriasis rosea responds well to ultra-violet radiation. The itching is relieved and the duration of the condition shortened. Mild doses of the rays given two or three times weekly are most efficacious.

Psoriasis.—As is well known, exposure to the sun (particularly the tropical sun) can cure this intractable condition. It is very rare to find lesions on any part of the body which is habitually exposed to the sun's rays. One would, therefore, expect ultra-violet radiation to be successful in the treatment, and this is the case.

Patients who have not had a previous attack, and where the onset has been rapid, respond most readily to actinotherapy. Either the air-cooled or the water-cooled lamp may be used to produce the necessary third-degree erythema.

If three or four exposures, spread over a period of seven or eight weeks, are given after all signs of the lesions have disappeared, there is practically no fear of relapse in this type.

Generalized psoriasis, especially if the patient has had several attacks, is more resistant to treatment, but it will clear up after repeated doses. This type is more prone to relapse, and the patient must recommence treatment immediately the first sign of return is noticed.

The type most commonly seen—namely, the large plaques on the knees and elbows, and often also scattered over the body—responds well to intensive treatment. If the patches are well localized the water-cooled lamp with compression is perhaps the most beneficial. The surrounding skin must be well protected and prolonged exposures to the thickened areas are often necessary; two or three applications of X-rays often expedite cure.

It is advisable in severe cases, if the reaction is

not too rigorous, to apply a mild keratolytic ointment between exposures, but the patient should have a hot bath and remove all the ointment, and as many of the scales as possible, before another irradiation.

In this type the treatment should be carried on for two or three weeks after the disappearance of the lesions.

We have recently succeeded in curing a case of twenty years' standing, with radiation, when all other forms of treatment, including injections of manganese, had been unavailing.

After irradiation the scales reappear much more slowly, and the lesions become less coarse and indurated—after a time they disappear and are replaced entirely by normal skin. The conjoint use of injections of manganese and ultra-violet radiation will shorten the time necessary to effect a cure.

In psoriasis we find it very difficult to give a correct prognosis at the commencement of treatment. Some cases do extraordinarily well and others do not seem to respond at all.

We have had both successes and failures with localized types, and also with widely spread lesions, but it is generally easy to say whether the result is going to prove satisfactory after treatment for a week or two.

Rhinophyma.—We have treated mild forms of this condition with ultra-violet radiation, using the air-cooled lamp for the purpose. Severe forms are best dealt with surgically. A second-degree erythema is produced. The whole appearance of the skin improves wonderfully after a few exposures, and the usual contrast between the red nose and paler colouring of the

other parts soon disappears in the general pigmentation which follows the radiation. Appropriate dieting is also helpful.

Rosacea.—Mild hyperæmic forms of rosacea can be satisfactorily treated with ultra-violet rays from the air-cooled lamp by producing a second-degree erythema. In more severe cases, such as the telangiectatic and hypertrophic types, compression treatment with the water-cooled lamp is necessary, a blister dose being given. The results obtained are equally as good as those with X-rays, but without the dangers associated with the latter.

Inflammations of the Deep Epidermis

Acne vulgaris.—Acne, especially in its milder forms, responds very favourably to actinotherapy.

In its most obstinate forms, which have resisted treatment with vaccines, medicines, soaps and ointments for years, marked improvement is generally obtained after the first few applications; but when there is keloid formation or much induration, and also when there is a tendency to relapses, conjoint Röntgen-therapy is necessary to bring about complete cure.

In acne the general condition of the patient is very important, and at first about half-a-dozen general exposures should be given for their tonic effect. Constipation should be avoided, plenty of open-air exercise taken, with a plain diet and an avoidance of greasy and sugary foods.

The depth of the lesions has a great influence on the time required for cure, superficial lesions clearing

up much more quickly than indurated. Comedones should be expressed before treatment, and if pustules are present these should be evacuated. It is advisable also to clean the skin with spirit before exposure.

Heavy exfoliative reactions are necessary. The desquamation results in the shedding of all but the deep-seated lesions; bacteria are killed and the erythema stimulates the flaccid superficial muscles and the anæmic skin itself. The secretion of the sebaceous glands becomes thinner and less abundant. For ordinary acne vulgaris, without induration, only four or five treatments are required. We have found that the chest and back respond to the treatment more quickly than the face; probably shaving may account for this, as the heads of pustules are incised by the razor blade and the infection spread.

In very stubborn cases weekly exposures to X-rays are very helpful. X-rays directly inhibit the activity of the sebaceous glands, and this is very useful in cases which tend to relapse.

Sycosis.—Mild forms of this disease will respond to ultra-violet radiation with the mercury vapour lamp. A mild exfoliative reaction is all that is required.

In the more resistant chronic type heavier dosage and more patience are necessary; compression treatment with the water-cooled lamp is often most beneficial.

The treatment should be continued for two or three weeks after the disappearance of the condition, to avoid relapse.

Alopecia.—*Alopecia areata* especially gives remark-

ably successful results with irradiation, which is considered the treatment *par excellence* for this condition. Of the 104 cases of Nagelschmidt who completed their treatment, 80 were completely cured, 16 improved and only 8 were not benefited.

With *Alopecia totalis*, out of 22 cases 14 were cured.

One doctor mentions two cases of almost complete baldness of some thirty years' standing which began a new growth of hair after six weeks' treatment with bi-weekly exposures. The improvement in the growth of hair is undoubtedly due to the erythema produced causing increased blood supply in the scalp.

Recent cases have, of course, the best prognosis. If the hair follicles are atrophied the results are not so good, and when the follicles have been destroyed by wounds no improvement can be expected.

Progressive cases, where hairs are still coming out, naturally do not give such good results with actinotherapy.

For small areas the "Kromayer" lamp should be used, with compression; for larger areas, the air-cooled lamp, producing a fourth-degree erythema, with an initial dose of ten to twenty minutes at twelve inches distance, the dosage being gradually increased.

Treatment should be reapplied when the previous reaction has faded, usually in seven to fourteen days. One application is sometimes sufficient to cure a recent case.

Men are naturally more easily treated than women. With the latter the hair has to be parted and retained in position during treatment. The ears, neck and face have to be protected with a towel.

The regrowth of hair usually commences in ten to twenty days from the commencement of actinic treatment. Fragile white lanugo hairs first cover the site of the lesion, and these are gradually replaced by normal hair, which in several of our cases has been darker than the original hair.

Alopecia seborrhœica has already been mentioned. Ultra-violet radiation is useful in *Alopecia præmatura.*

When treating ringworm and impetigo on the scalp, and when the hair covering and surrounding the lesions is cut short, we have noticed that it grows with great rapidity and needs repeated clipping every two or three days. After irradiation has ceased the cut portions are soon indistinguishable as the clipped hair regains its normal length so quickly.

Lichen planus.—Ultra-violet radiation is sometimes useful for relieving the irritation which is often so troublesome in the acute stages of this disease. A second-degree erythema is produced, which is repeated when the first reaction has disappeared.

However, in the cases we have treated, we have never found any improvement in the lesion itself. Resort has usually to be made to X-rays, especially in chronic cases affecting the shins.

Onychia.—Varying results can be expected in treating onychia with ultra-violet rays, from the fact that onychia is a term describing any inflammation of the nail, matrix, nail bed or fold. We have had successful results with the cases we have treated.

General treatment, giving a first-degree erythema, should be combined with local applications of the air-cooled lamp. For local irradiation we use the velvet

curtain attached to our own housing; the hands (or feet) are laid flat, with fingers outstretched, and at the first irradiation five minutes at twelve inches from the burner can be given safely; this can be increased

FIG. 145.—The K.B.B. "Kerr Russell" Housing being used for the Treatment of a case of Onychia. The Detachable Curtain is seen in use.

later to fifteen minutes at eight inches. The curtain prevents any rays falling on the arms or face.

Treatment is generally very prolonged, owing to the inaccessibility of the parts, even if the nail has been enucleated, but the results obtained are well worth the trouble.

The difficulties are greatest when the inflammation affects the nail-fold or the matrix.

Tinea (*tonsurans, circinata*).—This disease readily responds to ultra-violet radiation, especially when the lesions occur on the body.

The best method of treatment is by means of the "Kromayer" lamp, in actual contact with the lesion, for two or three minutes. An acute reaction results, and in early cases this is often sufficient to effect a cure.

Larger lesions must be treated with the air-cooled lamp, and the treatment is more prolonged. Third-degree erythema doses should be given, as it is not convenient to give blister doses to large areas.

In resistant cases copper ionization can suitably be combined with actinotherapy.

If the patches are on the scalp (*Tinea tonsurans*) a larger number of applications is generally necessary. The hair over the lesions must be cut as short as possible to ensure maximum irradiation.

Actinotherapy, though perhaps not so efficacious as Röntgen-therapy, is certainly less dangerous.

Local Infective Inflammations of the Corium

Erysipelas.—This streptococcal skin infection responds very well to ultra-violet radiation.

The inflamed area and one inch of surrounding skin should be irradiated with the water-cooled lamp, a third-degree erythema dose being given. The air-

cooled lamp can also be used and the following dosage given :

First application . .	10 minutes at 27 in.
Second ,, . .	12 minutes at 18 in.
Third ,, . .	15 minutes at 12 in.

We have treated a number of cases, and have found that if irradiation is given early enough one application is generally sufficient. The pain is relieved immediately. Even in the most severe case it is never necessary to give more than five exposures. Irradiation should be given every day.

Furunculosis.—Septic lesions, boils, carbuncles, ischio-rectal, mammary and alveolar abscesses yield readily to radiation from the air-cooled or water-cooled mercury vapour lamp. Sugar in the urine is not a contra-indication to ultra-violet treatment, but it indicates the need for a much more guarded prognosis. We ourselves tested the effect of ultra-violet rays on cultures of staphylococci, and found that exposures of five seconds at a distance of ten inches from the air-cooled mercury vapour lamp were sufficient to kill the organisms.

The local action on the lesion is directly bactericidal, and there is an increased blood supply to the part, with an augmentation of the lymphocytes and phagocytes. A single lesion is most effectively treated with the water-cooled lamp ; if it is in its early stages a single application, with the quartz compressor producing a blister, will often abort the condition altogether, or cause the lesion to subside rapidly without pus formation. If pus is present it should

be evacuated before actinic treatment, and then a severe erythema should be produced by an exposure at a very short distance from the burner. In every case an area half-an-inch beyond the circumference of the lesion should be irradiated.

Patients who are subject to septic conditions should undergo general irradiation also, so that the bactericidal action of the blood may be augmented and the resistance of the whole body increased. The pigmentation, which occurs, also protects the skin from bacterial invasion.

Thus, ultra-violet radiation is invaluable as a prophylactic agent when treating patients with low resistance to pyogenic organisms.

The old-fashioned poultices which used to be so greatly in vogue in treating these conditions are often the means of spreading the infection and causing secondary lesions. We have never known secondary pustules develop in a case treated with ultra-violet radiation.

In a case of refractory carbuncle—a condition which occasionally occurs—an application of X-rays will often hasten cure.

Benign Pemphigus and Dermatitis herpetiformis.—Actinotherapy will not cure these conditions, but it will prevent relapses. Mild doses should be given.

Lupus erythematosus.—Good results can be obtained by the use of ultra-violet radiotherapy in this intractable disease. Phototherapy should never, however, be employed in cases where dissemination is occurring.

Both the telangiectatic and scaly forms do well

with general irradiation, particularly if injections of a special gold preparation are given at the same time. Local treatment with the "Kromayer" lamp is, however, most important, and very strong doses of five to thirty minutes with compression should be given. We have often noticed after the reaction has subsided that the irradiated area is easily distinguishable from the adjacent untreated parts, because it is so much paler.

Diathermic cauterization is sometimes necessary in refractory cases.

There is no skin disease about which so many contradictory opinions regarding the value of actinotherapy have been expressed as in *Lupus erythematosus.*

At the Lupus Hospital, Vienna, where they have probably had more experience than any other institution, actinotherapy is the treatment chosen.

Soft Chancres have given satisfactory results with ultra-violet radiation. In the early stages irradiation with the water-cooled lamp under compression gives the best results.

If suppuration has taken place the pus must be evacuated before irradiation. Irradiation hastens healing in fistulous and ulcerated forms. The time taken to cure the condition varies, of course, with its severity, and ranges between a fortnight and four or five months.

Obstinate cases sometimes occur, when two or three exposures to X-rays will hasten resolution.

Syphilis.—Ultra-violet radiotherapy is invaluable in the treatment of syphilis. In this disease there is usually a very poor general state of health, and severe

anæmia is nearly always present. General irradiation quickly relieves these conditions and increases the defensive mechanism of the blood, and there have been cases where the Wassermann reaction was positive before irradiation and negative afterwards. There is no doubt that ultra-violet radiation increases the tolerance of the body to drugs. Cases having antisyphilitic treatment which are not responding well, and where syncopal attacks and vomiting are occurring, do well if the injections are stopped and general ultra-violet radiation substituted for a few weeks, and then the two forms of treatment given in conjunction.

Lesions such as secondary rashes, ulcers, gummata, osteitis, etc., respond rapidly to irradiation; this is best given locally and generally. A description of a case has been published in which a tertiary sore healed with five local applications, and another where a hard chancre healed in ten weeks, with a disappearance of the inguinal gland enlargement. Rollier has obtained satisfactory results in the treatment of syphilis by combining heliotherapy with antispecific medicaments.

New Growths

Keloid.—Concentrated ultra-violet rays, using the "Kromayer" or "Finsen" lamps with compression, have given good results. Kromayer advises strong doses of half-an-hour with the blue Uviol filter. Other workers prefer ultra-violet radiation used conjointly with radium. We have found the former method very satisfactory.

Nævi pigmentosa.—These blemishes can be removed satisfactorily by giving blister doses of ultra-violet rays.

The "Kromayer" lamp with a compressor is the most convenient apparatus to use, and the surrounding skin must be effectively protected by means of chamois leather, lead-foil or, most conveniently, with adhesive plaster. In some cases a single application will remove a mole, but generally two or three are necessary. The exposure should not be repeated until the reaction from the previous one has faded.

Diathermic cauterization with sparks or carbon dioxide snow also gives very satisfactory results, but the skin covering the site of the lesion is nearest normal after the use of ultra-violet rays.

Capillary Nævus, or Port-Wine Stain (*Nævus flammeus*).—Electrolysis, X-rays, radium, carbon dioxide snow and ultra-violet rays are all used in the treatment of this condition. The difficulty in treating these lesions can be realized when it is remembered that the dilated vessels are actually in the skin itself, and that it is necessary to cause their occlusion with as little damage as possible to the surrounding tissue. There is no doubt that this can best be achieved by means of ultra-violet irradiation under compression, as no permanent scar follows the most severe reactions, and the skin texture quickly assumes its normal characteristics, apart from some pigmentation which may persist for several months, but this is negligible compared with the original disfigurement.

The "Kromayer" lamp should be used with quartz compressors about an inch in diameter.

If the lesion is small (about one or two inches in diameter) it may be treated at one sitting; otherwise certain areas of the lesion, as widely separated as possible, may be irradiated on the same occasion, and others chosen at the next until the whole area is cured. Exposures lasting from five to twenty minutes should be given, and a month must be allowed to elapse before a certain area is again irradiated. Thin, non-hypertrophic cases which disappear on pressure give the best results, and sometimes only one exposure to each area is necessary to eradicate the condition.

When deep blue coloration is present treatment is more prolonged, and when there is hypertrophy of the tissues a good deal of patience is necessary on the part of both doctor and patient.

Occasionally exposures of sixty minutes' duration to one area are required, and failure must sometimes be acknowledged in very deep-seated lesions. An emollient cream should be applied to the area which has been irradiated. Healing generally takes place in from seven to ten days, and after each application the lesion becomes lighter in colour, until it is normal.

Xanthelasma palpebrale.—Concentrated ultra-violet rays from the "Finsen" or "Kromayer" lamp will cure this condition. Lomholt considers that actinotherapy gives much better cosmetic results than excision. Sometimes one application only is necessary, but more often two or three are required.

Stellate Veins.—Spider nævus (*Nævus araneus*) is generally treated by electrolysis, but ultra-violet radiation with compression will give equally good results. Only one or two treatments are required.

Telangiectases often occur after prolonged X-ray treatment in such cases as exophthalmic goitre, and are very unsightly; they may, however, be cured by irradiation.

Blister doses with the water-cooled lamp, using compression, should be given so as to induce the necessary *Arteritis obliterans.* One or two treatments only are needed, and the cosmetic results are very satisfactory, as only a faint white scar remains after the reaction has completely disappeared. We have treated a case of *Keratosis pilaris* of the axilla with actinic radiation without any improvement resulting.

Ulcers (*varicose, perforating, syphilitic, chancroidal and tubercular*).—Chronic indolent ulcers, however caused, should be treated by ultra-violet radiation.

Patients suffering from chronic ulcers are invariably found to have a decreased blood calcium content; therefore general irradiation must be carried out in conjunction with local treatment in these cases.

Actinotherapy causes an increase in the blood calcium and bactericidal properties of the blood, and improves the general health.

Locally, a severe reaction is necessary. The lesion must be carefully cleaned and all pus and crusts removed before exposure. The result is a direct bactericidal action on the organisms on the surface of the ulcer and an increased blood supply to the part, which stimulates the growth of healthy granulation tissue. After the first one or two exposures great relief is felt from the irritation and pain which often accompany the condition, and new epithelial formation can be noted round the edge of the lesion. This epithelium

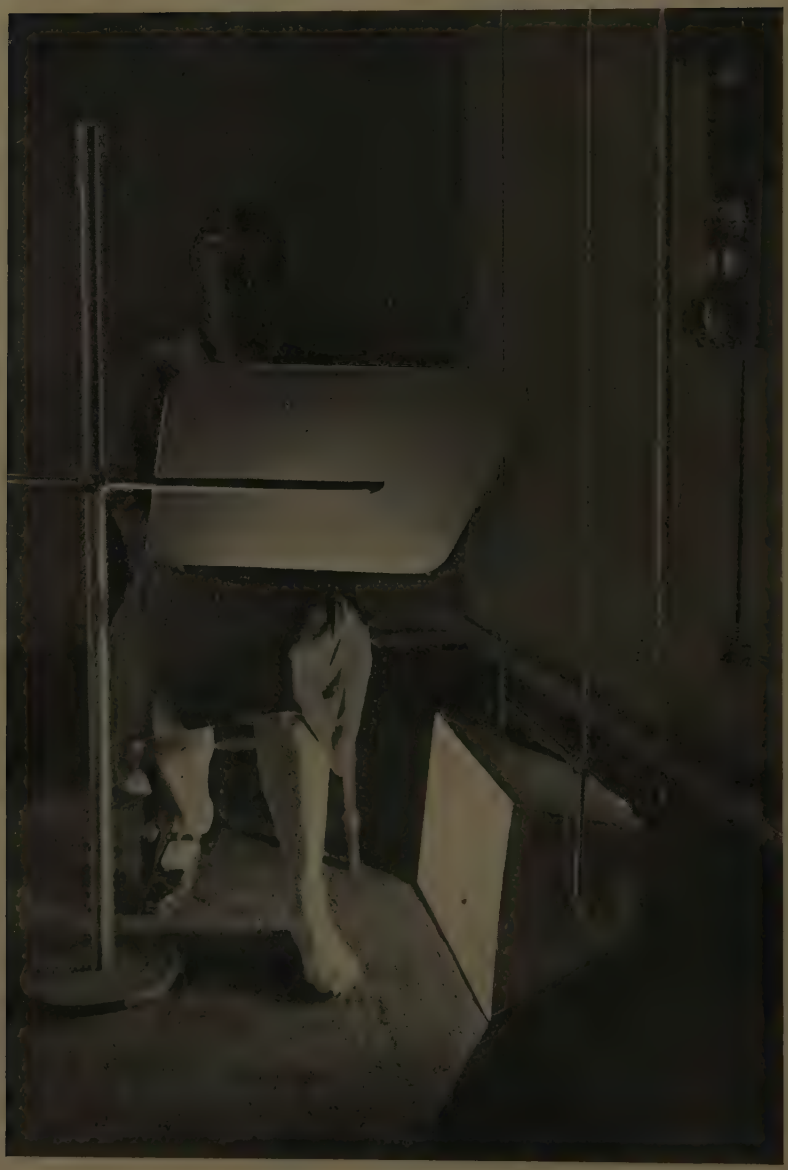


FIG. 146.—Illustration showing the adaptability of the Authors' Suspension Housing, manufactured by Kelvin, Bottomley & Baird. The Lamp is being used for the Irradiation of the Ankle in a case of Varicose Ulcer. The Screen is protecting the patient's face and hands.

is very delicate, and great care must be taken to protect it from destruction during subsequent exposures, so that it is often advisable to use the blue "Uviol" filter after the first two or three applications, and also to cover the new epithelium during irradiation.

Weekly or bi-weekly treatments are advocated. Some refractory cases heal more quickly if zinc ionization is carried out in conjunction with the ultra-violet radiation.

In old-standing lesions, where a large amount of cicatricial tissue is present, diathermy, X-rays or radium may be applied to soften the scar tissue before commencing actinotherapy.

Granulating Wounds also yield rapidly to the influence of phototherapy. The exuberant granulations become normal, and healing soon results from the stimulation of the epithelial growth. In these cases a stimulative erythema must be produced.

Skin Grafts.—Better results are obtained if ultra-violet rays are applied, as they have a sterilizing effect and also stimulate epithelial growth.

Bedsores.—General irradiation should be given, to increase the calcium content of the blood and improve the general condition of the patient. A stimulative erythema (second or third degree) is beneficial if applied to the site of a threatened bedsore. Long-standing lesions need treatment similar to that given to chronic ulcers.

Anomalies of Pigmentation:

Cloasma.—Good results have been reported with ultra-violet radiation.

Leucoderma.—Improvements in cases of leucoderma

have been obtained. Pigmentation has been developed in the achromic areas and has lasted several months. Areas which are normally uncovered have been found to respond better than those which are screened by clothes.

A Few Illustrative Cases

Baker's Dermatitis.—Case 1. A man, aged 35, a baker by trade, came with a moist eczematous condition affecting both arms from the fingers to the elbows. The arms were exceedingly irritable. Prolonged medicinal treatment had proved unavailing. On eight occasions the arms were irradiated with the air-cooled mercury vapour lamp, and at the end of that time the skin was perfectly normal.

Eczema.—Case 2. Female, aged 28, came to us suffering from extensive patches of eczema in each axilla, which were discharging profusely. She had been treated for several months, by different medical men, with various lotions and ointments, without appreciable success. Mild, sedative doses of ultra-violet rays were given, and after nine applications, spread over a period of three weeks, the condition was entirely cured. Several months afterwards there had been no recurrence. This case was particularly interesting, as it was one of the worst cases of regional eczema we had ever seen.

Eczema.—Case 3. Female, aged 30, had eczema on the dorsa of both hands for seven years. Medicinal treatment had been entirely unavailing. In all thirty-one applications were given with the air-cooled lamp

and two with the water-cooled. After a few treatments the condition healed, but subsequently broke out again. Now the lesions are satisfactorily healed and there has been no recurrence for over fifteen months. The first exposure with the air-cooled lamp was two and a half minutes at a distance of thirty-six inches, gradually increasing to ten minutes at eight inches. Only the hands were exposed to the rays.

Eczema intertrigo.—Case 4. Female, aged 46, had suffered from very severe eczema intertrigo for four years. It was associated with intense pruritus and pain, and great difficulty in walking. She had treatment from several doctors, without any improvement resulting. She was treated with a multiple arc lamp, using special white-flame carbons. After the second irradiation the lesion looked better, but there was no alleviation of the pruritus. The condition was cured with fourteen applications of ultra-violet radiation and four of X-rays.

Chilblains.—As already mentioned, this condition is, in our opinion, best treated by a combination of ultra-violet radiation with Schnee sinusoidal baths, and we have adopted this method with beneficial results.

Case 5 is a typical case. He had had chilblains on the hands and feet for years, those on the hands generally breaking. After four combined treatments, as described above, the condition completely cleared up, and so far there has been no recurrence.

Case 6. We had a curious case a short time ago of a woman who stated that she had sat at an open window

for a considerable time in her nightdress, watching something on the street, and a few days later came complaining of coldness in the breasts. On examination the breasts were found to be cyanosed and cold, as if caused by a condition of venous stasis. The erythema produced by one application of ultra-violet radiation gave immediate relief, and the chilly feeling was followed by a comfortable warm glow. The same result could probably have been obtained with oil of mustard or a mustard plaster, but the radiation was more pleasant and equally efficient. A week later the beneficial effect had not waned, and there was no subsequent return.

Herpes.—Case 7. Female, aged 64, had very marked *Herpes zoster*, which formed a band five inches wide and twenty long, round the left side of the abdomen and back. The pain was very marked, and the patient stated she had been unable to sleep for a week. After the first application of ultra-violet rays, of two and a half minutes at twenty-four inches, there was a complete cessation of pain, and she slept soundly at night. In all, she had nine exposures, spread over a period of four weeks, the last two being accompanied by diathermy (auto-condensation couch). The lesions healed with very little scarring, and there was no subsequent neuralgia, which so often follows this condition in elderly people, and generally proves so very intractable.

Case 8. Male, aged 18 years, suffering from herpes of the face, was cured with four exposures to the rays, extending over one week, the herpetic lesions disappearing with the resultant desquamation.

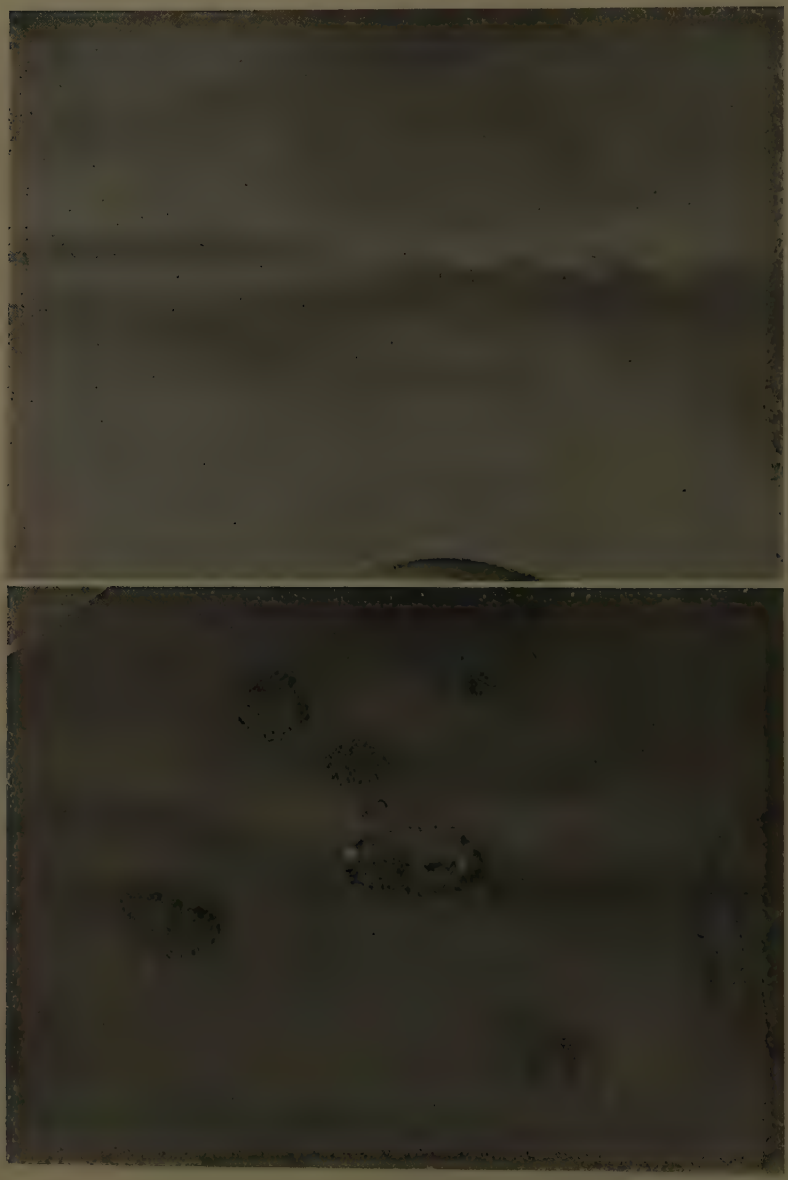
Impetigo.—Case 9. Female, aged 19 years, had an

impetigo of the chin which was rapidly spreading. An exposure of two minutes at ten inches from the mercury vapour lamp was given, which caused a smart reaction and immediately stopped the spread of the condition. The following day an exposure of four minutes at ten inches completed the cure. The application was followed by profuse desquamation, and at the end of the week the skin was again normal. We have treated a large number of children with this condition, and have been uniformly successful.

Psoriasis.—Case 10. Female, aged 42, had had this condition for over twenty years on various parts of the body. She had been treated with ointments, including chrysarobin, and recently had undergone a course of injections of colloidal manganese. There was an improvement with the latter, but the lesions on the knees and elbows remained. After thirteen exposures to the mercury vapour lamp the lesions were practically unnoticeable, and the patient has been able to wear sleeveless gowns for the first time for many years.

Case 11. Male, aged 35, a very severe case of psoriasis, being practically covered from head to foot with lesions. He is a seafaring man, and consequently has been unable to come regularly for treatment. He gave us an interesting account of the effect of natural sunlight on his condition, stating that when he was trading in the tropics, and was able to expose his body systematically to the sunlight, the condition completely disappeared in nine months, but returned four months later when he came home.

Case 12. Female, aged 48 years, had psoriasis for



A B

FIG. 147.—A Case of Psoriasis of Thirty-One Years' Duration, which was entirely uninfluenced by Medicinal Treatment but was rapidly cured by exposure to Ultra-Violet Rays: A, Case 12's back before Irradiation; B, after Irradiation.

thirty-one years. There were very large indurated patches, principally on the abdomen and back. The condition was completely cured after thirty-one applications of the air-cooled quartz mercury vapour lamp to the whole body, and fourteen applications of the "Kromayer" lamp to different areas. Several months afterwards there had been no sign of relapse.

Case 13. Female, aged 55 years. Had psoriasis for many years; the lesions were small, being about the size of a shilling, and uniformly distributed over the body and limbs. She was completely cured after seventeen applications of the air-cooled mercury vapour lamp. A year has now elapsed and there has been no sign of any recurrence.

Case 14. Male, aged 48 years. Has had psoriasis for fourteen years. Medicinal treatment has been entirely unavailing. General treatment with the mercury vapour and carbon arc was given on twenty-five occasions, local treatment with the "Kromayer" lamp on ten, and three applications of X-rays were made. A large area on the abdomen showed improvement where the compressor of the "Kromayer" lamp had actually been applied: the skin became almost normal. Later the condition became as bad as it had been before treatment, and many new lesions appeared on the back. Treatment had therefore to be discontinued, and it seems definitely established that it is unwise to continue actinic treatment if there is ever an acute exacerbation with the appearance of new psoriasis lesions.

Acne.—Case 15. Male, suffering from acne on the front and back of the chest, of twenty years' standing.

He had tried many forms of medicinal treatment without any improvement. The first application to the back, followed as it was by desquamation, apparently cured it, but subsequently another crop of pustules appeared. However, the condition was finally cured with a total of twelve applications, extending over a period of five weeks.

Case 16, a case similar to the former, was cured in seven applications, extending over three weeks.

Cases 17 and 18. Recently we have treated two cases of *Acne rosacea*, one of which had had a prolonged course of vaccine treatment without any favourable result. Ten applications completely cured one case, and thirty-five irradiations with the air-cooled mercury vapour lamp the other. A year afterwards there had been no relapse.

Alopecia.—Case 19. Female, aged 30, came to us suffering from *Alopecia areata*, there being a circular patch two inches in diameter on the occipital region of the scalp. An exposure of five minutes at a distance of thirty inches from the mercury vapour lamp was given, which was gradually increased to six minutes at eight inches in seven weeks. Fine downy growth of hair was noticeable over the area, which was faintest in the centre of the lesion, the hairs being so fine that they could hardly be seen. Fourteen days later hair was found to be thicker and covering the whole area. A week later the area was completely overgrown. The hair appeared normal, and could scarcely be distinguished from the surrounding hair.

Case 20. Male, aged 22. Had large patches of *Alopecia areata* on the back and sides of the head,

of six months' duration. The condition became worse while treatment with lotions was being applied. The "Kromayer" lamp was used to treat the different areas individually, and exposures of five to seven and a half minutes at a distance of four inches were given. The lesions were all uniformly covered with

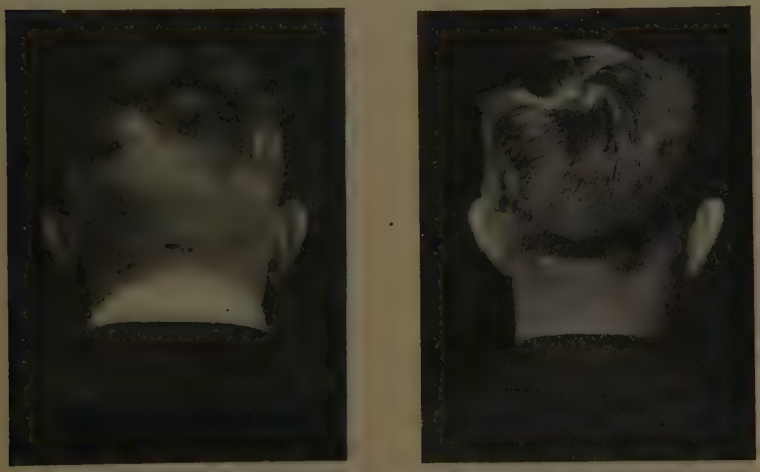


FIG. 148.—Case 20: *Alopecia areata* before and after Treatment.

fine lanugo hair after four exposures. Fresh lesions, however, developed, and eight further irradiations became necessary. The hair is now perfectly normal, except that the new hair is much darker than that covering the rest of the head.

Another case, 21. A man of 43 had had *Alopecia areata* for eighteen months. Five weekly exposures with the "Kromayer" lamp were sufficient to cover the patch with fine white hair, which was gradually replaced by normal hair.

Cases of seborrhœic baldness in men have been

treated, but progress is slower than in cases of *Alopecia areata*, where ultra-violet radiation can almost be counted a specific remedy.

Tinea.—Case 22. Girl, aged 4, suffering from widespread lesions on the back, abdomen and legs. All the lesions had completely disappeared after five applications of the rays, and no subsequent recurrence occurred. This case was of interest as several other children in the family were being treated for the same condition at a clinic, and in their cases progress was extremely slow, the condition remaining uncured after several weeks.

Tinea tonsurans.—Case 23. Boy, aged 4, had several lesions, varying in size from a threepenny piece to a two-shilling piece, scattered over the scalp. In this case copper ionization with bare copper electrodes and ultra-violet radiation were applied on the same day. Four exposures spread over a week completely cured the condition.

Lupus erythematosus.—Case 24. Male, aged 36, had extensive lesions on both cheeks. Five local applications with the "Kromayer" lamp were given; intense reactions resulted, with marked œdema, and when these had subsided, in about a week, areas of skin corresponding in size to the applicator appeared to have become quite normal. General treatment was also given.

Chronic Onychia.—Case 25. Female, aged 34, came complaining of onychia affecting all the digits of both hands. The condition had been in existence for a year. The fingers were exceedingly painful and tender, so that she had difficulty in using them at all. Local

and general treatment were combined, the air-cooled mercury vapour lamp being used in each case. The condition of the fingers was splendid after forty treatments, spread over a period of five months. Three months later there had been no recurrence.

Carbuncle.—Case 26. Female, aged 46 years, had a very large carbuncle situated on the posterior surface of the lower part of the chest wall. The condition was very extensive and wide incisions had to be made. An area in the centre of the scar was very intractable, and refused to heal under ordinary treatment. After six applications of ultra-violet rays the wound had completely healed.

Very rapid healing was achieved in the case of a granulating wound, resulting from a scald, on a child's arm.

Chronic Ulcers.—Case 27. Female, aged 65, had suffered for twelve years from a varicose ulcer situated on the lower third of the right leg. It was accompanied by a good deal of varicose eczema and consequent irritation. Various kinds of dressings had been applied, including bismuth subgallate and Unna's paste, and the patient had rested for months in bed without any favourable result.

During the first week of ultra-violet treatment applications were given daily. After seven days the itching, which had been almost unbearable, had entirely disappeared, and the ulcer itself had healed. Applications were continued thrice weekly for the accompanying eczema, and by the end of ten weeks the whole condition had completely cleared up, pigmentation only remaining. This is a typical example

of several cases treated in which we have obtained equally good results.

Ischio-rectal Abscess.—Case 28. Male, aged 26, had had several ischio-rectal abscesses, extending, at intervals, over a period of four years. A short time ago he came complaining of a lump in the ischio-rectal area. The lump was tender, about the size of a hazel-nut, but not fluctuant. After the first application of ultra-violet rays the condition aborted. Subsequent weekly doses were given to allay the slight pruritis which was present, and as a prophylactic measure against further infection.

Port-Wine Stain (*Nævus flammeus*).—Case 29. A lady with a port-wine stain about the size of an olive on the forearm, just below the elbow, was cured with two applications of the "Kromayer" lamp. Compression was applied, and exposures of fifteen and twenty minutes given at an interval of a fortnight. A curious feature about this case was that on each occasion the reaction did not appear after irradiation until an interval of 112 hours had elapsed.

CHAPTER XI

ULTRA-VIOLET TREATMENT IN TUBERCULOSIS

Comparison of Results obtained by Natural and Artificial Irradiation — Tubercular Skin Lesions — Glandular Affections—Bone and Joint Lesions—Tubercular Peritonitis—Pleurisy—Phthisis Tubercular Laryngitis—Genito-Urinary Tuberculosis—A few Illustrative Cases

THE great benefit derived from fresh air and sunlight in tuberculosis is, fortunately, universally acknowledged at the present time, and every patient, from whatsoever type of the disease he is suffering, should be sent, as soon as possible, to the country, where he will get the maximum of these essentials. Undoubtedly the best resorts for patients suffering from early tuberculosis are to be found in the High Alps, but, unfortunately, at present, these are within the reach of only a very small proportion of the thousands of sufferers from this disease.

There is surprisingly little difference, if any, in the results obtained at Leysin, Alton and Copenhagen. At Leysin natural sunlight is used; at Alton this is replaced on sunless days by artificial ultra-violet radiation, while at the Finsen Institute, Copenhagen, artificial sunlight only is used. The following Table compares the results obtained by Dr Rollier and the Finsen Institute:

Disease	*Finsen Institute*	*Dr Rollier's Clinics*
	Recovered	*Healed*
Tuberculosis of hip-joint .	78 per cent.	70 per cent.
Tuberculosis of knee .	70 ,,	71 ,,
Tuberculosis of ankle .	93 ,,	82 ,,
Tuberculosis of hand and wrist	88 ,,	55 ,,
Tuberculosis of elbow .	94 ,,	93 ,,
Tuberculosis of shoulder .	93 ,,	84 ,,

Seventy per cent. of the patients attending the Finsen Institute are over fifteen years of age, and the great majority are out-patients, often living in none too healthy homes.

Rollier's patients are living in hospitals situated in the High Alps and under his personal supervision.

Finsen's brother-in-law, Professor Reyn, says the results obtained by the application of carbon arc light baths in the treatment of surgical tuberculosis are brilliant.

Affections of bones, joints, skin, glands, peritoneum and the genito-urinary system all respond very favourably to ultra-violet irradiation, and the results have been so satisfactory that this should always be the treatment of choice. Operations, such as the aspiration of abscesses and removal of sequestra, have, of course, to be performed.

Children naturally respond more quickly to treatment than adults; recent cases heal in shorter periods than old-standing ones, and lesions of small joints are

cured more rapidly than those of large. It has been found that old fistulous bone conditions of the pelvis, spine and hip, and uncomplicated tenosynovitis are least responsive to radiotherapy.

Cases of phthisis require great care during irradiation. Early cases are the most satisfactory, but those in which the condition has become generalized, with nightly rises in temperature, and especially if hæmoptysis is present, are better left unirradiated.

If irradiation in a case of phthisis is followed by the slightest rise in temperature, or quickening of pulse rate, it is wisest to discontinue the treatment—at any rate, for a time. General irradiation of the body must always be given in conjunction with local exposures in every case of tuberculosis, whatever the type.

Tubercular Skin Lesions

Lupus.—This was the first disease treated by actinotherapy. Professor Finsen no doubt chose it because it was so resistant to all ordinary forms of treatment, and caused such a great amount of suffering.

The dry nodular type is probably the most amenable to phototherapy; lesions on the body or limbs are more easily cured than those on the face, and lesions on the ear and mucous membranes are the most difficult to heal.

The rays are so easily absorbed by the blood in the capillary network of the skin that it is necessary to make the affected area anæmic by compression with a quartz lens, to ensure the maximum action of the rays during exposure. A strong reaction with blister

formation should be caused, so as to destroy the diseased area and promote the growth of healthy tissue.

The extreme sensitiveness of the tubercle bacillus must be remembered, and this, together with the leucocytosis and increased bactericidal property of the blood, is probably responsible for the cure of the condition.

General and local treatment should be given and great attention paid to hygiene, and to the provision of plenty of nourishing food.

Dr Sequeira, of the London Hospital, finds that the combination of general with local treatment increases the percentage of cures in cases of lupus from 60 to 90 per cent. In many cases of tubercular lesions general irradiation alone, without local exposures, will clear up the condition, and in lupus the results have been found to be equally good even if the lesion itself has been covered over during irradiation.

Sir Norman Walker, in his *Introduction to Dermatology*, 1925, referring to ultra-violet treatment, says:

"For extensive cases of lupus no other method even distantly approaches it in efficiency, and I have little doubt that it will soon be available in all considerable centres." And again: "With a large experience of lupus—more than a thousand cases have passed under my notice—I feel bound to say deliberately that under no other method of treatment have I seen such rapid and satisfactory improvement as in those treated by one or other of the 'sunshine lamps.'"

In cases of lupus, phototherapy should be advised rather than X-ray treatment, especially in the nodular types, where carcinomatous changes are so apt to occur.

At the Lupus Heilstatte, Vienna, the combination of local and general light baths is given for large lupus lesions on the face, body and mucous membranes. Short-flame carbon arc baths are given and the exposures increased from the initial one of fifteen minutes to two hours. Light baths are taken two or three times weekly. Local treatment is given with either the "Finsen" or "Kromayer" lamps.

Dr Maar, of the Finsen Institute, Copenhagen, says that the "Kromayer" lamp can successfully compete with the "Finsen" lamp; and Dr Neisser, of Breslau, states that in his experience the "Kromayer" lamp has given results that were quite equal to the "Finsen-Reyn" lamp. It is interesting and useful to know this, because in private work the use of the "Kromayer" lamp makes it possible to save a great amount of time and expense.

Good results are obtained in old-standing cases, which require skin grafts, if the part is rayed both before and after operation. The area is first rendered sterile and, later, mild doses stimulate epithelial proliferation.

Lupus cases in hospital are treated usually with the "Finsen" lamp: four cases are dealt with by one lamp. In many hospitals automatic compressors are now used, instead of the applicators being held by specially trained nurses.

The initial dose is generally of ten minutes' duration, and this is gradually increased to an hour. An intense reaction with blister formation follows exposure, and another application is not made until the reaction from the last has subsided.

The "Finsen" lamp is too expensive and cumbersome to be used in private practice, so the "Kromayer" lamp generally takes its place.

Quartz applicators, corresponding in size to the

FIG. 149.—Local Treatment of Four Patients with the "Finsen" Lamp (50 ampères) at the Finsen Medical Light Institute, Copenhagen.

lesion to be treated, are used, and a steady pressure is maintained during treatment.

An exposure of five minutes is given at first and the blue Uviol filter is used if the area to be treated is very sensitive; otherwise it is inadvisable to filter the radiation. The exposure may be gradually

increased to thirty minutes. These sittings are followed by very intensive reaction and are repeated after intervals of two or three weeks.

As many as eight applications to one particular area may be required. After treatment it is customary to apply a soothing ointment. The following prescriptions are very useful:

℞ Paraffin molle, 4 parts. Ung. zinci, 1 part. Adeps lanæ, 5 parts.	*Or*	℞ Zinci oxidi, 2 parts. Amylli. trit., 2 parts. Olei olivæ, 1 part. Adeps lanæ, 1 part.

Pyrogallic acid dressings may be applied to the part, particularly if it is extensive, a few hours before irradiation. It removes the crusts and opens the pores. Treatment is then given, without compression, about two inches from the window of the burner. Red rays may be combined with the radiation from the "Kromayer" lamp, and are beneficial.

Excellent results have been obtained at the Lupus Heilstatte, Vienna, by this mode of treatment. Generally the centre of the affected area heals first and the edges remain active. Small areas of the peripheral nodules should be treated in turn with small lenses, and the centre area protected.

Diathermic cauterization of small resistant nodules is often helpful.

Very refractive cases of lupus are often benefited by injections of some gold preparation in conjunction with general or local phototherapy.

In the treatment of lupus of the mucous membrane of the throat, nose and mouth, by general carbon arc

baths, Strandberg, at the Finsen Institute, has had 87·1 per cent. cures.

Special prismatic quartz applicators are generally used for the local treatment of lupus affecting the nose, eyelids and mucous membranes of the mouth.

Before giving local irradiation for lupus the skin should be well cleansed with benzene to remove grease

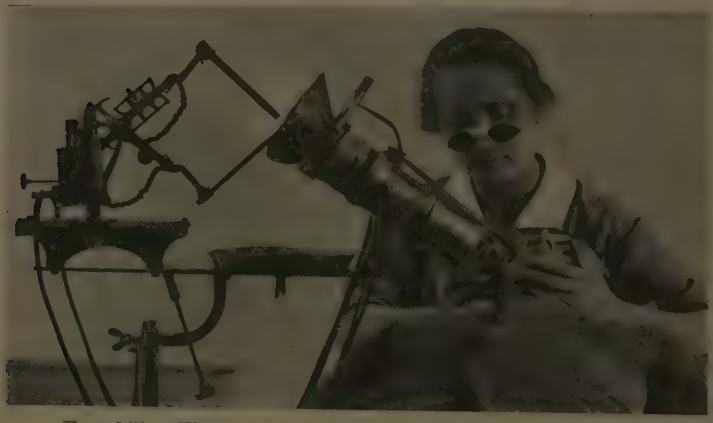


FIG. 150.—The "Finsen-Reyn" Lamp in use at the Finsen Institute, Copenhagen.

and scales, and half-an-inch of skin surrounding the lesion should be exposed. Dressings should be applied immediately after irradiation and not discarded until the reaction has subsided and healing taken place.

In every case of lupus the mucous membranes of the nose and mouth must be examined. At least two exposures should be given after the lesions have disappeared, and the patients should be examined at intervals of a few months after the termination of the treatment.

Treatment of Eyelids. – Lundsgaard's special

apparatus, with a quartz prism, is used with the "Finsen" lamp.

Gronholm's eyelid forceps are useful for everting the lids. Ten to thirty minutes' exposure is given,

FIG. 151.—Gronholm's Single Eyelid Forceps, for Eversion of the Eyelid. (Reyn.).

FIG. 152.—Gronholm's Double Forceps, for use during Irradiation of the Eyelids. (Reyn.)

and is followed by an intense reaction and swelling of the eyelids.

Lundsgaard's applicator is also very useful for treating the nasal vestibule with the "Finsen-Reyn" lamp. Special applicators can also be used with the "Kromayer" lamp.

Tubercular dermatitis and superficial ulcers also

heal very rapidly under ultra-violet radiation. A third-degree erythema should be produced at first over the lesions, care being taken to protect the surrounding skin. The ulcer soon becomes clean, and healthy granulations appear. The newly formed epithelium

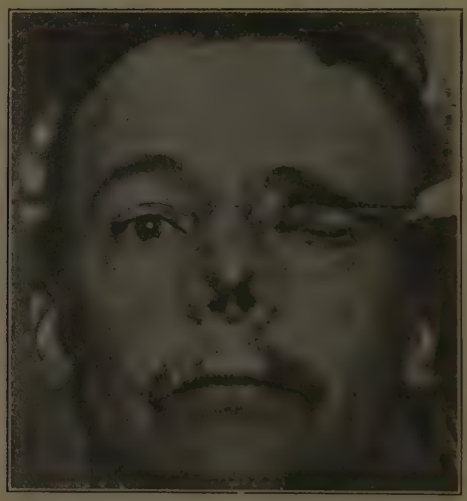


FIG. 153.—The Upper Eyelid everted with Gronholm's Forceps preparatory to Irradiation. (Reyn.)

which appears round the edges of the lesion should be carefully protected during subsequent irradiations. Exposures should be repeated as the reaction from the preceding one begins to fade.

Tubercular Glands.—The results with ultra-violet radiation are so brilliant that it is hoped that excision will soon become a thing of the past.

At the Finsen Institute it was found that only 40 per cent. of these cases were cured by X-rays, whereas 98 per cent. of the patients treated with ultra-violet

rays were cured, the average time to effect the cure being 4·8 months.

It is generally agreed that the carbon arc lamp is the most efficacious in these cases. Our own results,

FIG. 154.—Treatment of the Nasal Vestibule with a Prismatic Applicator. (Reyn.)

at first, with the mercury vapour lamp were not nearly so good as the Finsen figures.

There are three stages of the disease :

(1) Simple hyperplasia of the gland tissue.

(2) Where pus formation has taken place.

(3) Where the overlying skin has broken down and a fistula has resulted.

In the first stage general sun baths alone will effect a cure.

When pus forms it must be evacuated either with

a syringe, or the gland can be punctured with a special diamond-shaped stylet and the pus evacuated. In stages (2) and (3) resolution will be hastened if local treatment is applied as well as general. The cervical glands are those most commonly treated, but the peritoneal, axillary or inguinal glands are often affected, also the tracheo-bronchial glands, and in these cases the relief of dyspnœa is one of the first signs of improvement.

Some authorities consider that multiple tubercular glands respond to treatment most satisfactorily when there is periadenitis and a fistula, and that single glands covered with sound tissue yield best to X-ray treatment.

Enlarged mesenteric glands have been found to respond most quickly to ultra-violet radiation; the mediastinal glands next and the peripheral glands most slowly.

In tubercular adenitis strong local doses with the water-cooled lamp and compressors, combined with general irradiation, often expedites healing, third-degree erythemas being aimed at. If progress is very slow X-ray treatment should also be given. At first weekly doses, and later monthly exposures, are made. General ultra-violet baths are continued twice or thrice weekly throughout the treatment, the Dosage Table on page 247 being followed.

The internal administration of iodine is often helpful during the treatment of tubercular adenitis.

Tubercular Bone and Joint Lesions.—The effects of heliotherapy in this type of the disease are marvellous. Rollier at Leysin and Gauvain at Alton have both

obtained wonderful results, in two places, which are very unlike one another in climatic conditions; the most interesting point being the range of movement obtained in old ankylosed joints merely by insolation.

It is an extraordinary fact that the results obtained at the Finsen Institute with carbon arc baths are equally as good, as the following list shows:

RECOVERED CASES

	Non-complicated Per cent.	*Complicated* Per cent.
Tuberculosis of the wrist	86	90
,, elbow	88	96
,, shoulder	100	87
,, foot	100	87
,, knee	71	69
,, hip	100	57
,, spine	80	61
Tubercular teno-synovitis	12	100
,, dactylitis	100	98
,, peritonitis	75	57
,, disease of the female genito-urinary system	..	66
,, disease of the male genito-urinary system	66	85
,, caries of ribs and sternum	..	82
,, osteitis	..	94
,, osteitis of pelvis	..	55
Subcutaneous tuberculosis	..	92

The most striking difference in the results of treatment of tubercular joint disease by surgery and by

phototherapy is the dissimilarity which occurs in the amount of movement possible in the healed joint. Ankylosis generally follows excision of the joint; but a wonderful range of movement is usually possible after the more conservative radiotherapy, and naturally this is a most important matter to the patients.

Ernst did some very interesting work at the Finsen Institute on the Röntgen aspect of bone tuberculosis. He found that at the commencement of general ultra-violet radiation latent foci often manifested themselves and that they healed up after this period of reaction. He also often found that before any clinical signs had shown themselves the X-rays could reveal such conditions as tubercular dactylitis similar to the way in which pulmonary conditions are often diagnosed by X-ray examination alone. X-ray photographs taken before, during and after actinic treatment often show surprising differences. Complete recalcification of a bone which had apparently disappeared may occur, particularly in the case of small bones like the phalanges, the final appearance being that of normal bone tissue.

General irradiation with the carbon arc lamp is the method of choice in bone and joint tuberculosis, but the authors can also testify to the value of mercury vapour lamps in these cases.

In certain deep-seated cases conjoint Röntgen radiation may also be advisable. Naturally, great care must be paid to hygiene, diet and, particularly, to orthopædic measures to prevent and correct deformity.

In bone lesions, where there is much absorption of osseous tissue, the osteoblastic cells are stimulated;

the calcium and phosphorus content of the blood is increased and recalcification takes place; sequestra are often extruded, and new bone formation results.

When ultra-violet radiation is first applied there is usually an increased discharge from ulcers and sinuses, and some shedding of necrotic tissue in the form of sloughs or sequestra. This is soon followed by the formation of healthy granulation tissue and subsequent healing.

Irradiation plays an important part in getting secondary infection under control. In regard to the difficult question of prognosis the following figures from the Finsen Institute will be of interest:

Tubercular dactylitis generally requires two to six months for cure; more rarely, refractory cases may take as long as twelve months.

Tubercular Wrist.—Uncomplicated cases usually heal in six months; for complicated cases the average time is six to twelve months, and in a few cases this period is exceeded.

Tuberculosis of Elbow. — Of 31 cases: 4 cases recovered in three months; 3 cases recovered in six months; 8 cases recovered in twelve months; and the others took longer.

Tuberculosis of Shoulder.—Healing generally takes about six months in uncomplicated cases.

Tuberculosis of Ankle.—The average time for cure is six months.

Tuberculosis of Knee.—Recovery takes place in from nine to twenty-four months.

Tuberculosis of the Hip Joint.—Treatment must generally be given for twelve months or longer.

Tuberculosis of the Sternum and Ribs.—When sinuses are present, six to twelve months are needed for cure; occasionally cases heal in as short a time as three months.

Tubercular Osteitis.—The average time for recovery is one to two months; very severe cases may last six months, and cases affecting the trochanter of the femur even longer.

Tubercular Osteitis of the Pelvis.—Generally heals in twelve to twenty-four months.

Tubercular Peritonitis.—Actinotherapy is very useful in this disease and many cases can be cured by it.

With carbon arc treatment it has been found that 75 per cent. of uncomplicated cases and 57 per cent. of complicated cases recover. Confinement to bed is necessary in severe cases, and the usual hygienic and dietetic measures must be strictly carried out. In hospital, cases can be wheeled to the treatment-room in their beds, while for acute cases in general practice a portable lamp is necessary.

In favourable cases, from the commencement of treatment there is an amelioration of both the general and the local symptoms. The general state improves, appetite returns, fever disappears and weight is gained. Locally, pain and also ascites rapidly decrease, and the action of the bowels becomes more normal.

The most satisfactory cases are those where there is localized peritonitis, especially of the cæco-appendicular, hepatic or splenic regions, and when the disease is of the fibro-adhesive type. Lesions affecting the female genitalia also do well, healing usually taking place in from two to four months.

Cases of tubercular peritonitis of more severe types, especially when part of a generalized infection, do not respond so well; but there are some cases where great improvement has resulted from actinotherapy. If phototherapy alone is only partially successful, and a point is reached where the condition remains at a standstill, then greater improvement often follows the conjoint use of infra-red, ultra-violet and X-rays; or if the mercury vapour lamp alone has been used, improvement often results by substituting the carbon arc for it.

Intestinal tuberculosis complicating phthisis is generally of the ulcerative type, and characterized by pain and constipation, if the small bowel is affected, and by diarrhœa if the large.

Digestive trouble is the first symptom, and was formerly considered to be "the beginning of the end." Actinotherapy now offers some chance of recovery.

Irradiation, preferably with the carbon arc lamp, using special electrodes, such as polymetallic, to the abdomen, limbs and back, is advisable.

In advanced cases of phthisis, associated with hæmoptysis, the chest should be protected during treatment. The case must be watched carefully for any rise in temperature or pulse rate, and small doses at the beginning are safest.

Many of these cases do well, especially those with early lung symptoms. Pain and discomfort disappear after the first few applications, and the stools become normal after about three months.

Half the cases which respond well show signs of

definite improvement by the end of the first month of treatment.

Cases which do not improve with irradiation are generally those of very advanced pulmonary disease.

Pleurisy.—The pain of pleurisy is relieved by a second-degree erythema, and pleural effusions are absorbed in the same way as joint effusions and ascites.

Pulmonary Tuberculosis.—Ultra-violet rays can be safely used in pulmonary tuberculosis, provided there is no fever. The rays generally have a stimulating effect: patients have more energy, their appetite improves and weight increases. Treatment should be discontinued if there is any rise in temperature or pulse rate, or if there is progressive loss of weight.

Reyn recommends mild doses of fifteen to twenty minutes' general carbon arc treatment every other day, the exposure to be very slowly lengthened.

Oldenburg reports favourable results in pulmonary tuberculosis in fourteen out of thirty-eight children treated. The best method of irradiation for these cases is the fractional system described in the chapter on "Technique." If the case is an advanced one the chest should not be exposed during irradiation.

Tubercular Laryngitis.—Many cases of this disease will yield to actinotherapy even when they are secondary to pulmonary tuberculosis. Strandberg has published an account of one hundred cases with pulmonary involvement which he has treated with general carbon arc baths, showing 53 per cent. cured; ninety-seven of these patients suffered from hoarseness and in seventy-eight this symptom entirely disappeared, while in fifteen it was improved. Eight cases had

suffered from hæmoptysis and only two of these had an attack during treatment. The remaining ninety-two of these patients had no attacks of hæmoptysis. The average number of treatments given was eighty-six. General irradiation with either the mercury vapour or the carbon arc lamp must be given at least thrice weekly.

There are several forms of local treatment.

Dr Sorgo has evolved a method in which the patient applies the treatment himself. An adjustable head-band is fastened round the patient's head; to this is fixed a jointed wooden rod, which supports a mirror about six inches away from the face, and also a card-board screen.

The patient holds the tongue forward with one hand and supports a nickel laryngoscopic mirror with the other. With this he reflects the arc light on to the larynx, an image of which he should be able to see in the mirror.

The first exposure of five minutes is gradually increased to a total of an hour. The local irradiation can easily be carried out while the patient is having general treatment.

The "Kromayer" lamp can be used in these cases, with a special curved quartz applicator. An exposure of two minutes, increasing to five minutes, is given once weekly.

To combat the pain and dysphagia which is so often present in this condition Dr Ostermann, of Vienna, uses an inhaler attached to the spherical reflector of his air-cooled lamp. Half-an hour after a draught containing one gramme of potassium iodide the patient

inhales ozone generated by the lamp through the mouthpiece of the inhaler, which is plugged loosely

FIG. 155.—Dr Sorgo's Apparatus for Irradiation of the Larynx with Sunlight or the Rays from the Carbon Arc Lamp.

with cotton-wool, on which is placed a few drops of HCl and turpentine. This technique makes use of the fact that potassium iodide has a great affinity for ozone.

This treatment is repeated for twenty to thirty minutes every other day: the pain and dysphagia are often relieved after the first five or six treatments.

Dr Cemach's Method makes use of his specially designed stand, the "Photostat."

The patient lies on his back on a couch, with his

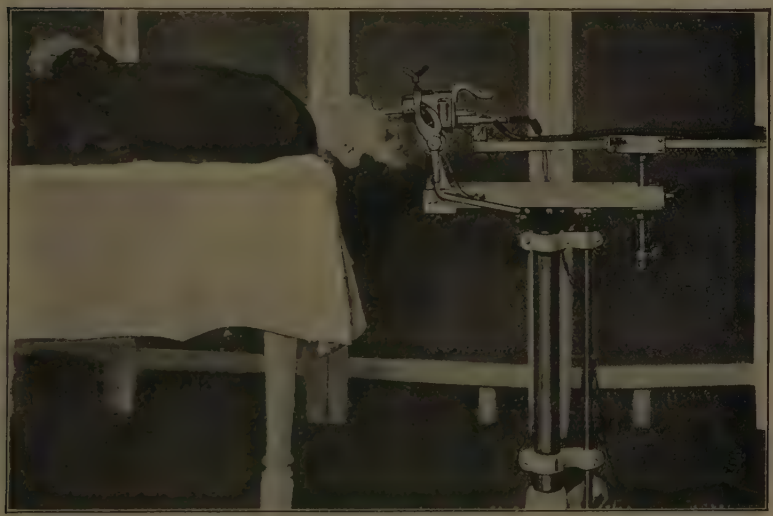


FIG. 156.—Dr Cemach's "Photostat" being used for Direct Irradiation of the Larynx.

head projecting partly over the end, his mouth open and his tongue out. A special hollow metal speculum is introduced into his mouth in the exact middle line. The uvula is first seen, then the stand is lowered and the speculum is adjusted so that the epiglottis becomes visible. The stand is again lowered and the larynx can be seen. The lamp itself is now simply swung into position and exposure commenced.

The speculum is easily removed at the end of

treatment. Two-minute exposures are given, and the treatment is continued generally for several months.

All early cases can be cured when the general condition is good, and 60 per cent. of advanced cases with good general condition.

The blue Uviol filter should be used for exudative cases of tubercular laryngitis. All cases of tubercular laryngitis should have sanatorium treatment and also tuberculin injections.

Renal Tuberculosis.—Ultra-violet radiation is invaluable in bilateral cases. There is often an early disappearance of hæmaturia, a cessation of pain and frequency of micturition, and a diminution of pyuria.

In cases where a sinus remains after nephrectomy radiotherapy will often cause rapid healing.

Tubercular Cystitis.—General irradiation should be given, and the female bladder can be treated locally by means of a special electrode, similar to McIntyre's, but made of fused quartz, and used with the high-frequency current.

In male cases, if there is a cystotomy opening the electrode can be introduced through it.

Tubercular Orchitis, Epididymitis and Prostatitis.—Good results can be obtained even in fistulous cases; the patients stand near the carbon arc and hold up the scrotum.

Tubercular Salpingitis may be treated also by general irradiation.

A Few Illustrative Tubercular Cases

Case 30. Woman, aged 36, had a large lesion, about the size of a hen's egg, over the right malar region. She was given altogether thirty-one general applications with the mercury vapour and carbon arc lamps and three local with the "Kromayer" lamp. The lesion disappeared completely, leaving a very smooth inconspicuous scar. The last twelve treatments were given after healing had occurred, with the object of preventing any relapse.

Case 31. Girl, aged 7 years, had had a patch of *Lupus vulgaris* on the right cheek for a year when she first came for treatment; it was the size of a shilling. The lesion healed perfectly with six applications of the "Kromayer" lamp, but three further treatments were given as a precautionary measure. Doses of two to ten minutes with a compressor were given. There is a pale scar of a lighter colour than the remainder of the cheek. The patient was seen six months after the termination of treatment, and the cheek was normal, but she was instructed to attend at regular intervals for examination.

Case 32. Woman, aged 32 years, had had a lupus lesion on the right cheek for thirteen years. The patch had been scraped and burned with acid on four occasions: it often healed for nine months after the operation and then broke down again. Eight applications of the "Kromayer" lamp, with doses of two to ten minutes with compression, caused the lesion to heal. Four further exposures were made. Another patch on the lobe of the right ear healed after four treatments.

Case 33. Male, aged 19 years. When he was seventeen a swelling appeared on the medial surface of the left thigh, about an inch above the knee joint. It was incised in hospital, but a large tubercular ulcer formed, about the size of a bantam's egg, which did not heal. General ultra-violet treatment with the mercury vapour lamp was commenced, and the ulcer, which had been present for two years, healed in six weeks, eighteen treatments being given. It has remained soundly healed now for nearly a year.

Case 34. Boy, aged 3½ years. Two and a half years ago a swelling appeared two inches above the left ankle joint. It was operated on at a hospital, and found to be due to tubercular osteitis of the tibia. After the operation it healed for a short while, and then broke down and formed a discharging sinus. General ultra-violet treatment with the air-cooled mercury vapour lamp was commenced on 28th January 1926, and the wound had soundly healed on 29th June 1926, fifty-two irradiations having been given.

Case 35. Boy, aged 3½ years. Tubercular dactylitis and osteitis. Swelling of the left ring finger, first noticed on 19th December 1924. Bone scraped in hospital on 13th August 1925, and a few days later the finger was amputated through the centre of the middle phalanx. A lesion which had appeared on the right humerus just below the shoulder joint was scraped on the 27th October 1925, and also another on the left middle finger. The surgeon told the mother that the left middle finger and also the left great toe would have to be amputated, and that ultra-violet treatment was of no value at all in a case of this nature.

Actinotherapy was commenced on 22nd December 1925, and general irradiation with the quartz mercury vapour lamp given. The finger healed soundly, and there was no further discharge after May 1926. The toe healed in July 1926. Treatment has, however, been continued since then, and the boy is exceedingly well and rapidly putting on weight. In all, one hundred and two treatments have been given, which certainly cover a considerable period; but this is well worth while, compared with the mutilating operations which are still, unfortunately, only too frequently performed. The multiplicity of the lesions in this case confirms the fact that tuberculosis is a general rather than a local disease.

CHAPTER XII

TREATMENT OF DISORDERS OF NUTRITION AND OF THE ALIMENTARY AND RESPIRATORY SYSTEMS

Disorders of Nutrition: *Diabetes mellitus* — Gout — Obesity — Rheumatism—Rickets—Bone Diseases—Effect of Ultra-Violet Radiation during Pregnancy. *Disorders of the Alimentary System*: Dyspepsia—Gastric Ulcer—Constipation —Diarrhœa—Cirrhosis of the Liver—Cholecystitis—Hæmorrhoids. *Respiratory Disorders*: Asthma—Bronchitis—Broncho-Pneumonia — Empyema — Pleurisy — Pleurodynia —Whooping Cough—A Few Cases

Disorders of Nutrition

Diabetes mellitus.—It is advisable to proceed very carefully when administering ultra-violet radiation to a diabetic patient: very mild dosage should be given at first and very gradually increased. There is a stimulation of metabolism and in some cases glycosuria disappears, and carbohydrate tolerance is increased, but results are irregular. Sampson and McCaskey consider it dangerous to administer ultra-violet radiation to a diabetic, and they describe cases in which a condition resembling anaphylactic shock resulted, and also others where there was a feeling of malaise accompanied by headaches. They believe that when a carbuncle fails to respond favourably to ultra-violet treatment a state of hyperglycæmia will also almost invariably be found.

Saidman, however, mentions several cases where there was a rapid diminution in the sugar content of the blood and urine following irradiation, and all the patients with glycosuria whom we have irradiated have derived benefit.

Gout.—Patients suffering from this condition benefit from ultra-violet treatment, particularly when it is applied generally. Either the mercury vapour lamp or the carbon arc may be used; they both increase metabolism, but the open arc is more useful on account of its stimulation of the skin and sweat glands.

A tepid shower bath after irradiation is beneficial. The usual dietetic and medicinal treatment must not be neglected. During an attack a second-degree erythema over the affected joint helps to relieve the pain. General baths with the mercury vapour lamp should be given, commencing with two minutes, and gradually increasing to ten minutes at thirty-six inches —or five minutes, increasing to sixty minutes, with the carbon arc. In chronic cases it is well to give an occasional monthly course of general treatment.

Obesity is due often to defective metabolism or glandular insufficiency. Ultra-violet rays are a useful adjunct in these cases, as they stimulate oxidization processes, and also increase the vitality of the patients —which makes them take more exercise. Bergonie treatment and radiant-heat baths can also be used.

Thin people generally increase in weight, owing to the improved muscular development which accompanies irradiation, especially with the carbon arc.

Acute Muscular Rheumatism, Lumbago, Muscular

Torticollis, Fibrositis, Chronic Rheumatism, Rheumatoid Arthritis.—These conditions all respond in

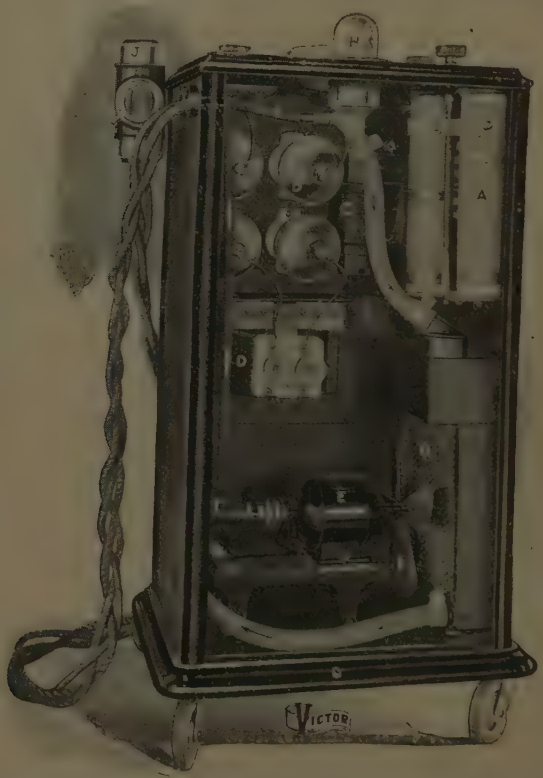


FIG. 157,—A Mobile Water-cooled Mercury Vapour Lamp with Self-contained Water-cooling System. (Victor Corporation, Chicago.)

A, Rheostat Control; B, Tungar Rectifier Bulb (4 used); C, Choke Coil; D, Transformer for Rectifier; E, Motor for Pump and Fan; F, Fan; G, Radiator, with Water Reservoir above; H, Water Flow Indicator; I, Water Circulation Pump; J, "Uviarc" Casing. Arrows indicate path of flow of water.

varying degrees to ultra-violet radiation. Pain is relieved and joint movement increased, and even

in old-standing cases of rheumatoid arthritis some alleviation can be looked for.

General irradiation is valuable as an aid to metabolism, and for the purpose of raising the bactericidal properties of the blood.

General hygienic measures, dental, vaccine and medicinal treatment, should also be prescribed. Local irradiation of the affected part should also be carried out. A third-degree erythema alleviates the pain and arrests the progress of the disease, and if fluid is present aids its absorption.

The conjoint use of infra-red and luminous rays, diathermy and, in some cases, X-rays with ultra-violet therapy is most valuable in rheumatic conditions.

In many cases of muscular rheumatism a single exposure to ultra-violet rays, causing a severe third-degree erythema, will effect a cure. Rarely are more than three or four séances necessary in the most severe cases.

Chronic rheumatoid arthritis is very resistant to treatment; cure is not expected, but pain can be relieved and movement increased. Naturally, early cases respond better than long-standing ones and subacute better than chronic. Acute cases must not be irradiated. Treatment is best given intermittently over a period of several months.

Fibrositis.—Case 36. Female—a typical example. She complained of pain over the erector spinæ muscle, which had increased in severity for two months until she was almost unable to walk. On the first day radiant heat was given, followed by ultra-violet radiation. A smart reaction was set up, and great

relief was experienced immediately. After seven subsequent exposures to the rays, given thrice weekly, the pain had disappeared.

We have treated various cases of indefinite pains of

FIG. 158.—Children being irradiated in an East London Clinic with a "K.B.B." Mercury Vapour Lamp.

"rheumatic" nature, which have generally responded to radiation.

Rickets.—Ultra-violet radiation may be safely regarded as a specific remedy for this disease. It was in 1890 that Dr T. A. Palm published his opinion that rickets was a "disease of darkness," and now this fact is universally acknowledged. The disease is mostly found in dark, squalid slums, but it sometimes occurs in better-class families too, where the diet is defective in fats, the nurseries are dark and the children are not taken often enough into the sunshine.

It has been proved by various experiments on animals, especially rats, that if they are fed on a

vitamin-free diet and are kept in darkness they will develop rickets and die, but if they are fed on the same diet, and irradiated for ten minutes daily with the quartz mercury vapour lamp, rickets will not occur. The beneficial effect is due to the immobilization of the phosphorus and calcium in the blood by the ultra-violet radiations.

If the phosphorus and calcium content of the blood be tested in cases of rickets it will be found to be lowered, but in each case the normal figure will be reached after a few irradiations. Fourteen days is the average time for this to occur.

Recently Professor Mellanby has shown that "if a minimum amount of fat soluble vitamin is present in the animals' food or tissues, exposure of the animals to ultra-violet rays will, up to a certain point, make good the deficiency in vitamin, thus promoting good growth and good bone calcification in animals fed on diets which would otherwise be inadequate for the purpose."

He has proved also that a deficiency of the anti-rachitic vitamin in the maternal diet during pregnancy makes the offspring more liable to develop rickets, broncho-pneumonia and other inflammatory conditions of the respiratory tract. This demonstrates the value of ultra-violet radiation during pregnancy.

Steenbock and Black have shown that exposure to the ultra-violet rays of a rat's food ration deficient in fat soluble vitamin caused it to become activated and produce as good growth and calcification of bone as if irradiation had been applied to the animal itself.

S. J. Cowell has been able to demonstrate similar

effects in the case of children suffering from rickets. Two rachitic children were given milk which had been exposed twice daily to ultra-violet rays in a wide shallow dish for twenty minutes at a distance of three feet from the lamp. A control case was given untreated milk. X-ray photographs of the wrist were taken before and after one month's treatment. The two X-rays of the control case showed that hardly any difference had taken place in the month, while in the case of the children fed on the irradiated milk a marked improvement in calcification had occurred.

Similar results have been obtained by irradiating dried milk for half-an-hour in thin layers one foot from the lamp. Subsequent boiling does not destroy the anti-rachitic property of irradiated foods.

Hess and Weinstock found that irradiated vegetable oils acquired anti-rachitic properties when exposed to the rays from the mercury vapour lamp, and that these oils, twelve months after irradiation, were still able to protect animals from developing rickets. These workers also discovered that the active principle was confined to the non-saponifiable fraction of these oils, and that it was contained in the phytosterol and cholesterol which form part of these substances; this is also the case with cod-liver oil. Phytosterol and cholesterol before they are irradiated have no beneficial effect on cases of rickets, but after exposure to a mercury vapour lamp they are able to protect animals from this disease, either when given by the mouth or introduced subcutaneously.

Skin is very rich in cholesterol, and Hess and Weinstock formed the opinion that it was the effect of the

ultra-violet rays on this substance in the skin which caused the prevention and cure of rickets by heliotherapy and actinotherapy, since the rays were unable to penetrate the whole thickness of the skin.

They, therefore, irradiated human skin, which had been removed from the body, and added it to the food of rats, who were being fed on a rickets-producing diet. These rats did not develop rickets, whereas the controls did.

Hess and Weinstock further found that if the irradiation of the skin is too prolonged a substance is finally produced which has no anti-rachitic properties. The time necessary for the activation of cholesterol is from one half to three hours, and this period should not be exceeded.

Parsons succeeded in curing a case of rickets, which had given no response whatsoever to several months cod-liver oil treatment, by administering irradiated cholesterol. This substance was thinly spread on a Petri dish and exposed for one hour to a "K.B.B." burner at a distance of one foot. A three-per cent. solution was then made by dissolving it in linseed oil. Doses of one drachm, and later two drachms, were given thrice daily.

Fish obtain vitamins from the diatoms and plankton which grow on the surface of the sea. These substances probably cause the wonderful phosphorescence which can often be seen on the sea during very dark nights. They have the power of elaborating vitamins from the sun's rays. The cod stores these vitamins in its liver, hence its value as an anti-rachitic medicament.

If fish oil is administered to patients suffering from

rickets, improvement in the condition is generally noticed. Laplanders, in the Arctic regions, where they dwell in darkness for six months, do not suffer from rickets, as their chief article of diet is fish oil. How it acts is not quite known, but it has been found that if cod-liver oil is oxidized, and specially prepared photographic plates screened by quartz filters are exposed to it, the presence of ultra-violet emanations can be demonstrated.

Clinically, it is found that the continued administration of cod-liver oil for a prolonged period of time will generally cure rickets. Occasionally, however, it fails. Treatment by ultra-violet light always effects a cure, and in a much shorter length of time. The conjoint use of the two methods of treatment gives the most favourable results.

It has been found, experimentally, that the rays in natural sunlight which accomplish the cure of rickets are those with wave-lengths between 3022 Å and 2900 Å, and in the case of the mercury vapour lamp those between 3022 Å and 2654 Å.

General irradiation of the whole body gives the best results, beginning with two-minute exposures of the back and front of the body at thirty-six inches from the mercury vapour lamp and gradually increasing the exposure until fifteen minutes to both back and front are being given at twenty inches distance, either daily or on alternate days. In rickets it is not necessary to induce erythema.

Huldschinsky advises the irradiation to be continued for as many months as the child's age in years, then to wait a month without giving treatment, and

after that to give a final month's further treatment. Other workers consider that two months' treatment

FIG. 159.—"Victor" Combination Air-cooled and Water-cooled Quartz Lamp Outfit; which can be used when there is no regular water supply available.

is sufficient for even the severest case, and we have found this to be so in our own practice. After the

course the condition is completely cured, and will never return.

All the symptoms which characterize this disease tend to disappear rapidly. The catarrhal condition of the lungs, stomach and intestines soon clears up, the appetite improves and the weight is increased. One of the most obvious changes which occurs after the first few irradiations is the alteration in the disposition of the child. A cross, fretful infant becomes happy and playful. In practically every case of rickets there is marked irritability; this is due often to digestive troubles, tenderness of the limbs, or simply to the general "poorly" condition.

Calcium is a nerve sedative, and if the amount in the body is insufficient fretfulness and irritability develop, often leading to spasmophilia, tetany, *Laryngismus stridulus*, and even to convulsions, which are so often seen in ill-nourished, rickety children.

The atonic condition of the muscles so often found in children suffering from rickets, and associated with tenderness of the limbs, is due partly to the low calcium content of the serum and partly to the decrease of phosphorus, leading to diminished conductivity of the nerve fibres supplying the muscles. Ultra-violet radiation soon rectifies this condition.

Another symptom which responds well, but rather more slowly, to actinotherapy is the anæmia. The red cells and their hæmoglobin content gradually increase, and become normal by the end of two or three months.

Bone Changes.—The epiphyseal enlargements quickly subside, and by the aid of X-ray photographs several changes in the bones themselves may be

noticed. The general fluffiness and swelling round the epiphyses disappear, the epiphyses themselves become clearly defined, lime salts are deposited in the shafts of the long bones, and cupping of the diaphyses disappears. New—yet very distinct—centres of ossification, which were not present before treatment, begin to appear. Children who have been unable to walk soon find their feet and are able to run about as normal children. Bony deformities, such as bow legs, often disappear in children under two and a half years of age. Craniotabes responds well to actinic treatment and gradually disappears.

Huldschinsky maintains that "the prophylactic treatment of rachitis ought to be introduced as universally as vaccination against smallpox. Every child, whether it shows any symptoms of rickets or not, should during its first year be exposed for at least a month to ultra-violet rays. If this be done there are prospects of seeing rickets as a disease disappear entirely. Cases of rachitis ought not to occur in any well-administered community."

If this were systematically carried out in hospitals and clinics there would be a considerable decrease in infant mortality from pneumonia, diarrhœa, convulsions, etc. Bow legs, kyphosis, scoliosis and many other crippling conditions would be unknown; maternal mortality at childbirth from flat and deformed pelvis would be greatly decreased, and the general health of the race as a whole would be improved.

It has been proved by work done at the out-patient department of the Children's Hospital, Boston, U.S.A.,

that acute rickets can be readily cured by ultra-violet radiation given in an out-patient department thrice weekly for two months. It is not necessary to use any anti-rachitic medication. Drs Wyman and Weymuller also found that in a series of four hundred babies (between the ages of three and eight months) who were attending the out-patient department, and who had not had cod-liver oil, 95 per cent. had rickets, while 100 per cent. of the negro and Italian children were affected before they were eight months old. In this country over 50 per cent. of all cases, between the ages of six months and three years, attending the Motherwell Child Welfare Centres in 1924-1925 showed some osseous sign of rickets.

The functional nerve disorders, spasmophilia, tetany, *Laryngismus stridulus* and convulsions, which have already been mentioned, react quickly and very favourably to ultra-violet radiation.

Convulsions are of reflex origin and generally due to such causes as dentition, constipation, or some other form of irritation, which would have no ill effects in the case of a normal child, but which provoke convulsions in rickety children owing to the decrease of calcium in the blood and the increased excitability of the nervous system. Two or three exposures to the mercury vapour lamp are often sufficient to prevent the occurrence of this alarming symptom.

Delayed dentition is another manifestation of rachitis which may be rectified by ultra-violet radiation, and we find that children who have had this treatment for any condition have very little disturbance or pain when cutting teeth. Altogether, the

results which can be obtained in treating rickets with ultra-violet radiation are so striking that no difficulty has ever been experienced in getting parents to bring their children for treatment, even though in so doing they have been put to a great deal of trouble and inconvenience.

If rickets is treated early enough no permanent bone deformities need be anticipated. With older children who already have shaft deformity the problem is more difficult, especially as it is almost impossible to get children living at home to wear suitable corrective apparatus. Osteotomy seems the only procedure in these cases. This can be done while irradiation is being carried out. Usually the fractures in the bones are soundly healed in four weeks, allowing the splints to be discarded at the end of this time.

Huldschinsky says operation should be avoided in *Rachitis florida*, as it may bring on tetany. He advises a thorough examination of the nervous system in all rachitic cases before operation.

We have had an opportunity of treating several cases of rickets, some of which were of the florid type with active joint lesions, accompanied by marked metaphyseal enlargement and deformity of the long bones associated with all the usual symptoms of this condition—*i.e.* prominent abdomen, bronchitis, diarrhœa, etc. We took a series of X-ray photographs of the wrist, ankle, knee and elbow joints before, during and at the end of treatment.

The radiograms taken before treatment commenced showed the presence of marked florid rickets, characterized by great enlargement of the epiphyseal areas,

Fig. 160.—A Case of Rickets which prolonged administration of Cod-Liver Oil failed to cure, but which rapidly yielded to Ultra-Violet Radiation. X-Ray Photographs of Boy's Wrist (Case 37).

A, Taken before commencement of Ultra-Violet Treatment, showing typical Florid Rickets; B, Same wrist two months later, showing Complete Cure.

which were indistinct, together with cupping of the lower ends of the metaphyses with irregularity and poor definition. There was also rarefaction of the shafts and slight periosteal thickening. The photographs taken after only five weeks' treatment showed a wonderful difference, with increased metaphyseal definition, clearly marked epiphyses, and the absence of cupping. This proves indeed that rickets is essentially a "disease of darkness." Ultra-violet radiation has won its place in therapeutics, if only for its wonderful power in this disease.

Case 37. A boy, aged 3½ years, was a typical case. He was the second youngest of a family of twelve, six of whom were living, and three of whom were suffering from rickets. At the commencement of treatment he weighed 1 st. 9 lb., and had never walked, and talked very badly. He suffered from bronchitis and diarrhœa, and was very fretful. After the first few applications of the rays the bronchitis and diarrhœa cleared up, he ate and slept well, and played about with his toys. Before this the child had been given cod-liver oil for several months without any noticeable effect, but the almost immediate improvement with ultra-violet radiation was most marked. The child was breast-fed until six months old, and then had a well-known brand of infants' food until a year old, after which he had food with the rest of the family, which would not be very nutritious, as the parents are poor. At sixteen months he was beginning to walk, when he developed measles, and made no further attempt to walk. He was treated at a clinic for rickets from that time without much benefit, and when we saw him marked

B

A

FIG. 161.—X-ray Photographs of Ankle of a Case of Rickets (Case 37), which prolonged administration of Cod-Liver Oil failed to cure, but which rapidly yielded to Ultra-Violet Treatment. Before the commencement of Actinotherapy, the child, though aged 3½ years, had never walked.

A, Taken before commencement of Ultra-Violet Treatment; B, Same, two months later.

deformity was present. The child had splints applied to prevent further deformity and to counteract as far as possible that which was present, but difficulty was encountered to keep them on at home.

After the first two or three weeks the bronchitis and diarrhœa had completely cleared up, and the child was much brighter.

At the end of treatment he was almost normal, talking well, and playing and running about with other children. Examination of the bones by X-rays proved that the rickets was completely cured. When seen eighteen months later he was strong and well, with no bony deformity whatsoever.

Bone Lesions.—Ultra-violet radiation is very useful for increasing the blood calcium and hastening reunion in the case of fractures of bone, which may have been caused surgically or by trauma.

Osteoporosis, which often occurs after fracture, or during illness, owing to disuse of the bones, can also be prevented.

Osteomalacia is essentially due to a deficiency of calcium in the blood during pregnancy, and results in the softening of the bones of the mother, and fœtal rickets (achondroplasia) in the child. Both these conditions can be avoided by means of antenatal ultra-violet radiation.

Osteogenesis imperfecta is a disease in which the bones are exceedingly brittle, and where fractures occur with the slightest injury. It also can be improved by actinotherapy.

Osteomyelitis cases do well with ultra-violet radiation, especially after they have been operated on.

Rollier has had exceedingly good results with heliotherapy.

Osteitis deformans (*Paget's Disease*).—We have had very satisfactory improvement in some recent cases of this rather uncommon disease. The spongy œdematous condition of the tibiæ soon show marked amelioration.

In all these cases general irradiation is necessary. Calcium should also be given orally, and small doses of parathyroid gland extract are often beneficial in conjunction with actinotherapy.

Case 38. Male, aged 55 years, suffering from *Osteitis deformans*. The condition was first diagnosed two years ago, when he was being X-rayed for a fractured clavicle, but undoubtedly it had been going on for some years previous to his accident.

There is two inches shortening in height and consolidation of the lumbar vertebræ into a rigid bony column. There is a curious fold in the skin of the abdomen which passes through the umbilicus.

Before commencing treatment there was wasting of both groups of gluteal muscles, and a boggy swelling of the upper third of the left tibia and the middle of the shaft of the right humerus.

The condition has yielded wonderfully to ultra-violet radiotherapy; the deformity, of course, persists, but the spongy condition of the tibia and the humerus soon disappeared, and it is now impossible to get any pitting on pressure over either of these bones.

General treatment was given for several months with the air-cooled mercury vapour lamp, the ordinary dosage being used.

The Effect of Ultra-Violet Radiation during Pregnancy.—Actinotherapy is invaluable during pregnancy. The increasing demands of the growing fœtus upset the calcium metabolism of the mother. It is thought by some that this calcium deficiency is responsible for eclampsia, as in this condition the blood calcium is extremely low.

Kehrer has noted a marked fall in the blood calcium during the later part of pregnancy. Pacini has found that ultra-violet radiation dispels tetanic or convulsive symptoms which sometimes occur towards the end of pregnancy and which he considers the precursors of eclampsia. From the mother's standpoint her general health is also benefited and metabolism is increased, diminishing the risk of constipation and auto-intoxication.

The value of antenatal irradiation to the fœtus is equally important, as even a slight diminution in the blood calcium of the mother may be detrimental to the child, causing the so-called rachitic diathesis. After birth this may lead to different symptoms, such as badly developed bones, irregular eruption of teeth, which rapidly decay, and a tendency to the development of florid rickets, with its various attendant symptoms.

Achondroplasia, as already mentioned, is another manifestation of calcium deficiency in the fœtus. The condition is due to abnormal development of the fœtal skeleton characterized by undersized limbs, attributable to the premature union of the epiphyses of the long bones.

If the infant is irradiated with the mercury vapour

lamp after birth improvement takes place, and the skeleton becomes more normal in appearance.

A case is recorded where the condition was diagnosed at the eighth month of pregnancy by means of X-rays. The mother was irradiated for fourteen days before delivery and the infant was practically normal.

General irradiation should be commenced about the beginning of the third month of pregnancy, and weekly applications given at first; later exposures can be made twice or thrice weekly.

Disorders of the Alimentary System

Dyspepsia; Gastric Ulcer; Constipation; Diarrhœa.—Ultra-violet radiation has proved particularly useful in cases of hyperacidity, chronic gastritis and duodenal or gastric ulcers. The pain of these conditions can often be relieved—probably, as Pacini points out, by a diminution of the acid content of the gastric juice following irradiation. The general health is improved and the blood-calcium deficiency, with the disturbance of hydrogen-ion balance, which is such a common symptom in these cases, is remedied.

Parathyroid extract and calcium lactate should be taken orally. The rays probably also have an important effect on the reflex cutaneous areas. A second-degree erythema should be produced daily, or every other day, over the front and back of the patient with the air-cooled lamp. Constipation is often relieved, probably by a tonic effect on the unstriped muscle of the intestines, or by stimulation of the endocrine glands, particularly the pituitary and thyroid.

Chronic diarrhœa and irritating catarrhal conditions of the bowels, such as mucous colitis, respond to this mode of treatment, owing to the disinfection of the bowel which results from the increased bactericidal power of the blood. Cases of nervous dyspepsia, where worry, anxiety and nervous exhaustion often have more to do with the condition than any actual lesion of the stomach, respond quickly to ultra-violet radiation, irritability disappears, patients sleep better and acid eructations soon disappear. Appetite returns and with it a generally happier feeling. The air-cooled lamp is most satisfactory in these cases.

We have also had rapid improvement in cases suffering, through nervousness, from imperfect control of the anal sphincters. The disturbing desire to defæcate at socially inconvenient times is soon relieved.

In the authors' practice spasmodic conditions of the alimentary tract, œsophageal spasm, pylorospasm and enterospasm have yielded satisfactorily to a combination of ultra-violet radiation and diathermy applied directly over the affected area. Spasmophilic vomiting and the vomiting of pregnancy are greatly benefited by actinotherapy.

Marasmic children generally improve with ultra-violet radiation. Little ones who have become a source of worry to their parents, who will not take their food, who are not thriving and are generally irritable and petted and prone to fits of crying, soon lose all these unpleasant little traits, rapidly regain their normal appetite, and become self-reliant and happy.

Cirrhosis of Liver; Cholecystitis.—Cirrhosis of the

liver and chronic inflammatory lesions of the gall-bladder are other conditions in which good results with ultra-violet radiation have been reported.

The improvement in these cases is obviously due to a lessening of the amount of blood in the portal system, owing to the larger amount circulating in the superficial skin areas.

Jaundice is benefited, especially if calcium salts, which combine with the bile pigments, are given by the mouth.

Hæmorrhoids.—Ultra-violet radiation has been used for the treatment of hæmorrhoids, the water-cooled lamp with a special quartz applicator being employed, but in uncomplicated internal cases diathermy with metal electrodes, with a dose of one ampère for fifteen to twenty minutes every second or third day, is probably more satisfactory.

Special electrodes, vacuum or, better, non-vacuum, can also be used with the high-frequency current, but diathermy is more beneficial. Operation is better resorted to for all external or complicated cases.

Cases of *Fistula* which have been incised and drained improve with actinic treatment, the water-cooled lamp having a direct bactericidal action on the lesion, and the general irradiation increasing the general resistance.

We have used ultra-violet radiation successfully in cases of ischio-rectal and perineal abscesses, also prophylactically in patients subject to these conditions, as previously mentioned.

Case 39. Female, aged 35, had been subject to violent attacks of diarrhœa and enterospasm when

there was any suggestion of going to a friend's house or to an entertainment, so that she refused to leave home. General irradiation with the air-cooled mercury vapour lamp was given, and after the second treatment there was a complete cessation of the unpleasant symptoms.

Disorders of the Respiratory System

Asthma.—Ultra-violet radiation should be tried in this disease, as many cases respond favourably in a short time, especially when the condition is of recent origin. The probabilities of cure are more remote in chronic cases, accompanied by an old-standing bronchitis.

In favourable cases the attacks are less frequent after ultra-violet treatment, and when they do occur are less severe in character. The improvement may be due to stimulation of the sympathetic and glandular systems.

The skin of asthmatic patients often shows abnormal sensitivity to actinic radiation, so that particular care should be taken when irradiating these cases. In adults the carbon arc seems to give the best results, and the inhalation of ozonized air may be of value.

Dr Saidman recently showed us a number of his asthma patients; some said they felt better after the first application, and had no further attacks after the second. Of fifteen recent cases of his, five were cured after the first application.

It is only fair to say that a number of cases show no improvement.

First-degree general irradiation should be given twice or thrice weekly.

Bronchitis.—Chronic bronchitis cases show improvement with actinotherapy, because ultra-violet radiation raises the resistance of the body to infection. The cough becomes less troublesome and, consequently, insomnia is often relieved; expectoration decreases.

Children who have persistent coughs without any physical signs rapidly respond. Cases where coughs have persisted for months, and have been a source of disturbance to a whole household, have been swiftly cured by ultra-violet radiation.

Bronchiectasis usually shows improvement.

Broncho - Pneumonia.—Ultra - violet radiation is useful in treating cases during convalescence; the return to normal health is hastened.

Empyema.—Ultra - violet radiation is invaluable in treating post-operative cases which have chronic sinuses; rapid healing is the rule.

Emphysema.—Apart from the improvement in the general health, actinotherapy has no effect in this condition.

Laryngismus stridulus has been mentioned already, in the section dealing with rickets.

Pneumonia.—Diathermy now seems the method of choice in treating pneumonia, but ultra-violet radiation is exceedingly useful in the convalescent stage.

Pleurisy can be benefited. In afebrile cases third-degree erythema doses should be applied locally to the site of pain. There is a marked counter-irritant effect; applications should be given twice weekly.

Pleurodynia.—Ultra-violet radiation and diathermy given conjointly are very useful in cases of pleurodynia which do not respond to medicinal treatment and where the general state of health is bad.

Whooping Cough.—We have found that this condition is very amenable to treatment by general irradiation with the mercury vapour lamp. The frequency and severity of the attacks of coughing are greatly reduced, and the general condition of the patient improved.

We have treated several children lately suffering from this distressing condition, with very gratifying success.

A few days after the commencement of the disease mothers have remarked that their children had not coughed during the twenty-four hours which had elapsed since the previous treatment. The children became much brighter and less fractious after the first few exposures, and played contentedly with their toys. They ate and slept well, and put on weight.

X-rays, applied to the neck and upper part of the chest, can sometimes be usefully combined with ultra-violet radiotherapy.

One very severe case will be given as an example :

Case 40. Girl, aged 3 years, a very delicate, frail, weakly child, contracted whooping cough from other children in the same house. For a fortnight she was in bed with a temperature ranging from 100° to 104°. The cough was very troublesome, especially at night ; she was very fractious, and the relatives got practically no rest, night nor day. As soon as it was possible,

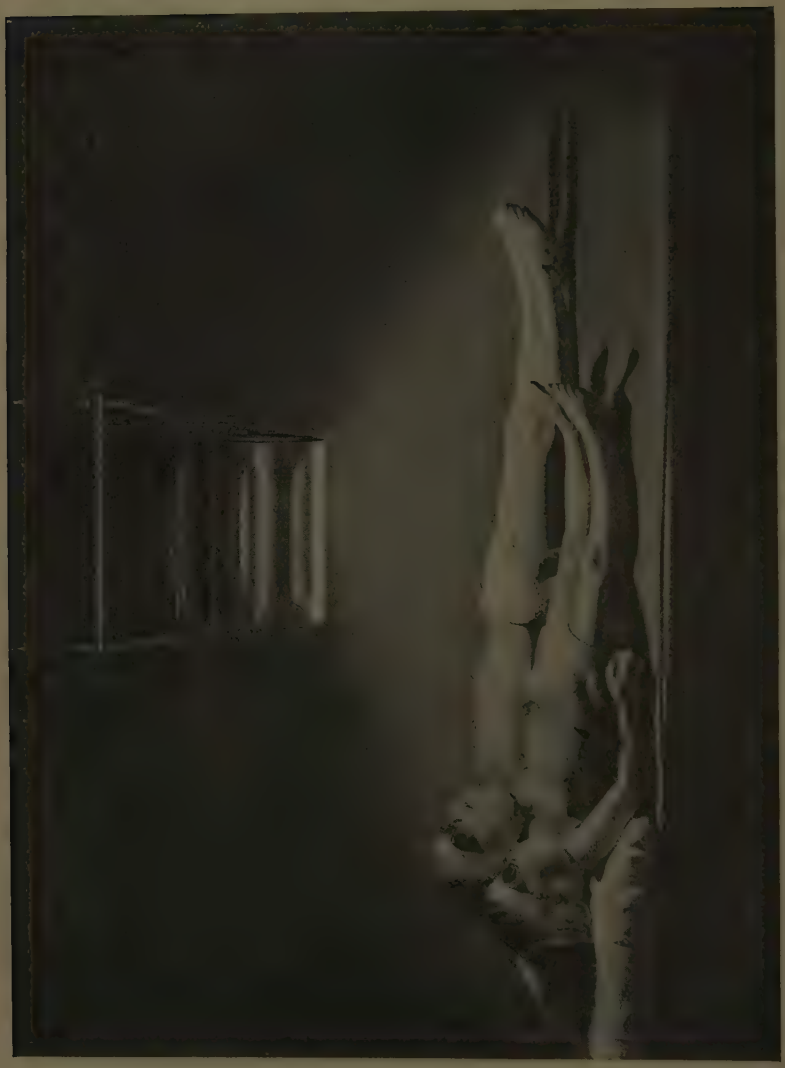


FIG. 162.—Two Children suffering from Whooping Cough being irradiated with one of our Lamps.

the child was wrapped in blankets and brought by car to our consulting-rooms for ultra-violet irradiation. The chest was first exposed for two minutes at thirty-six inches, and the area and dosage were gradually increased, until the whole body was exposed, back and front, each for fifteen minutes daily. The result was surprising.

After seven exposures the child was greatly improved, and the attacks of coughing very much less frequent. The mother stated that she had not coughed for fourteen hours, and was much more lively, and played alone with her toys. Four days later she had not coughed from one exposure to the next (twenty-four hours), and this improvement was maintained until the attacks of coughing had practically ceased. She ate and slept well, gained weight, and was soon almost a normal child again. Eighteen months ago this child commenced natural sun baths, out-of-doors when possible, and in a room with windows glazed with "Vitaglass" when outside conditions were not suitable. The child is now deeply pigmented, broad and strong and full of mischief, and able to tolerate extreme cold without any discomfort.

CHAPTER XIII

OTHER DISEASES IN WHICH ACTINIC RADIATION HAS BEEN USED

Actinotheraphy in Diseases of the Genito-Urinary System—Diseases of the Blood and Ductless Glands—Circulatory Diseases—Nervous Disorders—Mental Affections—Illustrative Cases—Infectious Fevers—Diseases of the Eye—Diseases of the Throat, Nose and Ear—Uses of Ultra-Violet Radiation in Dental Practice—Veterinary Uses of Ultra-Violet Rays.

Genito-Urinary System

Nephritis.—Mild irradiation may be given in the subacute and chronic stages of this disease with some beneficial effect. Pain, headache and insomnia are often relieved and diuresis increased.

Actinotherapy is very useful in the convalescent stage, for the purpose of toning up the general system.

In chronic nephritis good results are obtained, especially in tubercular cases, when irradiation often results in the disappearance of hæmaturia and the diminution of pyuria and pain. Results are not so hopeful when pulmonary infection is also present.

Ultra-violet radiation is being used increasingly now in the operating theatre, and Professor Leguen reports that nephrectomy cases less frequently develop fistula when there has been exposure to ultra-violet radiation during the actual operation. A special screened lamp suspended above the operating-table is used. We

have treated many cases of chronic nephritis associated with high blood pressure. Improvement has been noted in nearly every case.

It is a matter of conjecture what is responsible for this amelioration of symptoms. It may be due to an alteration in the blood condition, as anæmia is always a prominent symptom of these cases; or it may be due to a fall in blood pressure. A general improvement in metabolism, with the elimination of poisonous waste products, which would otherwise be retained and cause harmful sequelæ, may be responsible for good results in nephritis.

The increased bactericidal property of the blood after irradiation is also helpful in this condition.

Undoubtedly, the hyperæmia induced in the skin is also beneficial, and, unlike the hyperæmia caused by radiant-heat baths, it is lasting.

Cystitis, especially when it is tubercular, responds well. Saidman has obtained good results by means of a small lamp which may be introduced through the urethra into the female bladder, or through a cystostomy opening in the male. General irradiations are also given.

Orchi-epididymitis may also be treated by general and local irradiation with considerable success, especially in tubercular cases.

The most satisfactory method is general treatment, with the patient standing as near the carbon arc as the heat allows; the testicles are raised with the hand and the maximum radiation is allowed to fall on the affected area.

Prostatitis can be treated with the water-cooled

lamp. Quartz applicators are introduced into the rectum. Frequency of micturition and pain are alleviated. Some workers have had encouraging results in the treatment of enlarged prostate by this method. Sampson mentions some very successful results obtained by the conjoint use of diathermy and ultra-violet radiation.

Urethritis.—A special thin quartz rod is introduced into the urethra, and radiation from the water-cooled lamp directed through it. The rod is gradually withdrawn, so that the whole of the urethra is irradiated in turn.

Amenorrhœa.—One of the physiological properties of ultra-violet radiation is the stimulating effect it has on the menstrual flow. A stabilization of the calcium salts in the body may bring about this effect. In young girls the growing skeletal structure makes the first demand on the calcium salts in the body ; after its needs have been satisfied the salts can then be utilized for reproductive functions. If an increased amount of calcium is retained in the body the menstrual cycle generally becomes normal. Increased ultra-violet radiation in the tropical countries may account for the early appearance of puberty in these regions.

Amenorrhœa may occur at puberty, or later when there is anæmia, a poor state of health following an acute illness or endocrine maladjustment.

When associated with puberty Donelly recommends general ultra-violet irradiation combined with diathermy, the electrodes being placed over the epiphyses of the femora. This increases the flow of blood and

lymph to the shafts of the bones, raises their temperature, and causes the marrow cells to produce a greater number of red blood corpuscles. Slow electric wave-currents are also used to stimulate the uterus and the ovaries.

The authors have had good results in amenorrhœa with ultra-violet radiation alone.

Dysmenorrhœa.—The conjoint use of diathermy and ultra-violet radiation is ideal in this condition, which responds so unsatisfactorily to medicinal treatment. We find that general irradiation to the whole body with the air-cooled lamp, producing a second-degree erythema, is most successful.

Diathermy can be conveniently applied with the Schittenhelm couch used as the negative electrode, the positive being placed over the lower part of the abdomen. The strength of the current should depend on the size of the electrode, and this should be as large as convenient. Towels soaked in salt and water should be placed under the metal plate of the electrode, as a deep effect is desired. Treatment is best commenced about four days before the menstrual period is expected, and given daily, or every other day. Treatment can be continued even during the first day or two of menstruation if necessary. Excellent results can be anticipated.

Hysterical manifestations which sometimes accompany menstruation, and which may be due partly to the excessive excretion of lime salts at that time, are greatly relieved by irradiation, as it checks this excretion of calcium, which undoubtedly plays such a large part in the control of nervous irritability.

Sterility.—Certain cases are cured by ultra-violet treatment. If necessary, the cervix should, of course, be dilated and the uterus curetted. A better adjustment of the ovarian function results, and there is a stimulation of the nervous system. Three months' treatment is usually necessary.

Treatment at the Menopause.—We have found great improvement when patients have been irradiated at the menopause. Ovarian secretion is stimulated, and troublesome symptoms, such as irritability and flushings, disappear, high blood pressure is lowered, and the excessive deposition of fat, which so often occurs at this time, is controlled.

Menorrhagia and *Metrorrhagia* are often relieved. The anæmia which is generally present is improved, the calcium salts in the blood are increased, and the blood clots more readily; consequently, the vicious circle is broken.

Vaginitis.—General ultra-violet radiation and diathermy treatment are useful in vaginitis, though special applicators may be used with the water-cooled lamp.

Leucorrhœa associated with vaginitis has also been treated in the same way, but diathermy applied by means of a special egg-shaped metal electrode is so successful in these cases that it seems unnecessary to depart from this mode of treatment. The condenser couch can be conveniently used as the negative electrode, while the positive pole is attached to the special metal electrode by means of an insulated handle. The condition soon clears up; the unpleasant discharge ceases, and the excoriation of the skin which is so often present in cases of vaginitis disappears.

Erosion of the Cervix Uteri.—This condition has been successfully treated with the water-cooled lamp, a special quartz applicator being necessary.

Gonorrhœa.—The use of the "Kromayer" lamp

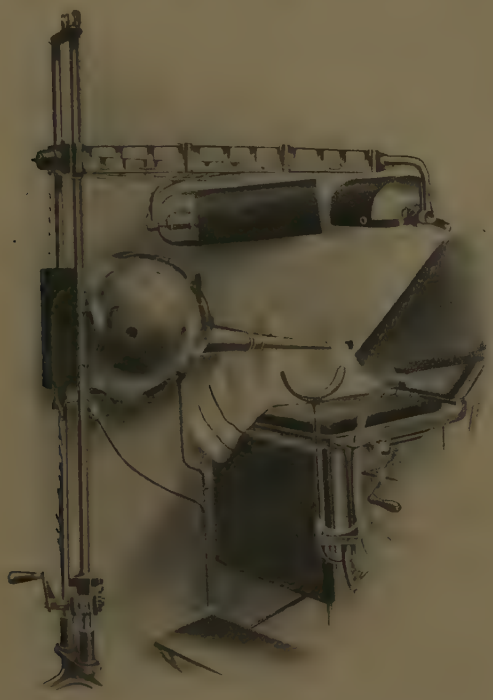


FIG. 163.—"Ultra Sonne" Carbon Arc Lamp and Carbon Filament Lamps arranged for Gynæcological use.

with special applicators has given indifferent results. Meatal lesions have proved most satisfactory.

Saidman advises an initial dose of half-a-minute, and each succeeding exposure to be increased by a minute; treatment to be given twice a week. He says

that if, after five applications, there is a decrease in the number of organisms in the discharge, continue the treatment. If there is not, stop it.

Incontinence of Urine.—We have recently treated a little girl who suffers from enuresis. She had no incontinence while having general ultra-violet radiation, but there was a return when the treatment was discontinued on account of some intercurrent affection. However no further trouble was experienced when irradiation was resumed.

Pyelitis due to the bacillus coli is benefited by actinotherapy. General treatment should be given.

Infantilism and Impotence.—Good results have been obtained in cases with deficient testicular secretion. In impotence there is improvement in cases where the general health is poor, or where it is associated with neurasthenia.

Menorrhagia.—Case 41. A girl, aged 17, had menorrhagia and metrorrhagia for some months. Amelioration was obtained after eight general irradiations with the air-cooled mercury vapour lamp.

Diseases of the Blood and Ductless Glands

Anæmia (secondary, pernicious); Chlorosis; Leukæmia.—Improvement in cases of anæmia with actinotherapy could be expected when the biological effect of ultra-violet radiation on the blood is considered, and such is the case. Cases of secondary anæmia, in convalescence after acute illnesses, in rickets, in pretubercular conditions, in nephritis and following hæmorrhage, chlorosis, splenomedullary

leukæmia, and even pernicious anæmia, all respond favourably to this form of treatment.

The air-cooled lamp, or preferably the carbon arc, is used and general exposures given to the whole body. The Dosage Tables on pages 247 and 263-266 should be followed.

The good results obtained in cases of chlorosis are due probably to the indirect disinfection of the alimentary tract, and the aid given to the absorption of iron, which should be given by the mouth during the treatment. There is an increase in both the number of red blood corpuscles and also in the amount of hæmoglobin. The general health improves, the colour returns, headache is relieved, the appetite becomes normal and consequently the weight increases.

We have treated cases of pernicious anæmia and have been able to bring about slight progressive increases in the number of red cells, the patients feeling much better for the treatment, and in some cases being able to attend work again. They were also relieved of the vomiting and other stomach symptoms. The glossitis which is so often present can be rapidly remedied by local irradiation of the mouth. The weight increases.

While realizing that pernicious anæmia is a disease characterized by remissions, there is no doubt about the beneficial effect of ultra-violet radiation. The value of open-air sunlight treatment in these cases has never been disputed.

Some cases of leukæmia have been successfully treated with actinic radiation. Pacini advises the administration of X-rays to the spleen, in conjunction with general irradiation with the air-cooled lamp.

Purpura ; Hæmophilia.—We have not had an opportunity of treating purpura or hæmophilia with actinic rays, but consider that benefit should be obtained, as the rays increase the calcium content of the blood, and calcium is essential for the clotting of the blood.

Endocrine Glands (affections of).—We have treated a case of hypothyroidism, with physiological swelling of the gland, successfully with ultra-violet rays ; and there is no doubt that the rays stimulate thyroid and pituitary secretion. Suprarenal asthenia is relieved by actinic radiation and the parathyroids also appear to be stimulated. Activity of the sexual glands is evoked by irradiation.

Hypothyroidism.—Case 42. The patient was an unmarried lady of 36 years of age. The condition had begun about twelve months previously, with a feeling of listlessness and exhaustion. There was soreness and tightness over the thyroid area, and some swelling was noticeable. The pulse was 48. Thyroid gland tablets were taken (5 grs. increasing to 30 grs. daily) for several months without result. Mixed-gland tablets were then tried without any benefit. Ultra-violet irradiation was commenced, and the patient stated that almost immediate improvement was felt. The swelling disappeared, together with the sore and tight feeling, which was noticed only when the patient was very tired. Six months later she felt better in herself, said she was more lively, ate and slept well, and that all she complained of was that she became easily tired.

Circulatory System

Patients suffering from the effects of high blood pressure, whatever be its causes, are greatly assisted by exposure to the ultra-violet rays. The erythema which is produced through the dilatation of the superficial vessels probably plays its part; but we have noticed in almost every case of hyperpiesis which we have treated that the fall in blood pressure is often immediate—that is, before the erythema has developed. It has been our custom to take blood-pressure readings just before treatment, and again just after. In many cases we have noticed that the pressure fell as much as 20 mm. after the first irradiation of two or three minutes at a distance of thirty-six inches from the lamp.

Naturally, cases due to functional causes respond best—cases where there have been severe emotional disturbance, mental repression and worry. But cases with definite kidney involvement, and considerable arteriosclerotic changes, do very well also.

We have taken blood-pressure readings some time after treatment has been discontinued, and have found that, although the pressure has generally risen when compared with the pressure registered immediately after treatment was stopped, it is invariably considerably lower than it was previous to the commencement of ultra-violet treatment.

Breathlessness on exertion, headache and irritability generally disappear. There was no fall in blood pressure in a few of the cases treated, but the patients said they felt wonderfully better after the course of

treatment, and several have returned again for a further series of applications. General irradiation should invariably be given, with a second-degree dose.

Functional heart conditions derive great benefit from actinotherapy.

We have had good results also in cases of valvular disease of the heart, where the heart was generally hypertrophied in an endeavour to ensure compensation; even in these cases the patients feel much better as a result of the treatment; but whether this is due to the fall in blood pressure or not is doubtful.

Dyspnœa and vertigo often disappear and insomnia is relieved.

In nine recent cases which we have treated, five of which were arteriosclerotic, one nephritic and three functional, with no ascertainable organic cause, we have had an average fall of systolic blood pressure of 30 mm. of mercury. Some cases respond much more quickly than others. One patient (Case 43) had twenty-three treatments, extending over three months. The systolic blood pressure at the commencement of treatment was 220 mm. of mercury, and at the end of this period was 190 mm. of mercury. Despite this comparatively small drop the patient said she felt immeasurably better after commencing treatment. She lost the languid feeling which generally accompanies this condition, and could get about much more easily, and eats and sleeps well.

Another case (No. 44) showed the surprising fall of 54 mm. of mercury, from 186 to 132, after two exposures, totalling eight minutes only.

Case 45. A functional case, with a systolic blood pressure of 162, fell to 119 after four treatments.

The whole subject is of great interest and importance, because cases of this condition have proved so intractable to treatment with drugs such as potassium iodide and the nitrites; and we have personally been unable to obtain with diathermy the results which other workers claim to have got.

Angina Pectoris.—Hasselbalch, at the Finsen Institute, used general carbon arc baths for cases of angina pectoris, with exceedingly good results. He produces a definite erythema, which relieves internal congestion, also dyspnœa and cardiac distress. In many cases the dilatation of the heart was reduced. Strikingly favourable and rapid results, which were quite lasting, were gained in forty-four cases of true angina pectoris.

We have had experience of the rapid way in which palpitation, dyspnœa and the oppressive feeling of tightness in the chest can be relieved; the attacks, too, become much less frequent.

Case 46. Female, aged 63 years, had suffered from valvular disease of the heart, auricular fibrillation and angina pectoris for several years. She obtained wonderful relief after eighteen general applications with the quartz mercury vapour lamp. Dyspnœa and pain disappeared, and there were no further attacks in the six months following treatment.

Raynaud's Disease.—Ultra-violet radiation is invaluable in Raynaud's disease.

The history of an interesting case which we have treated is as follows:

Case 47. Patient is now 28 years of age. When she was a baby a year old she had to have both little toes amputated for Raynaud's disease.

The condition gradually got worse, and when she was nineteen it became necessary to amputate, first, the great toe and second toe of the left foot, and then the left leg itself below the knee. She now wears an artificial leg. Three years ago a sinus developed on the sole of the right foot, over the head of the middle metatarsal bone. This was scraped soon afterwards, but continued to discharge; a sequestrum was extruded, but the lesion did not heal. The lesion had the same appearance as a perforating ulcer.

Local ultra-violet treatment with the mercury vapour lamp was commenced on 6th May 1925, and after seventy-four applications the foot was soundly healed on 13th November 1925. The foot has now remained healed for over a year.

Senile Gangrene.—As soon as there is any evidence of disturbed circulation the air-cooled lamp should be used to produce regenerative erythema, a second- or third-degree dose being given. If the skin is broken and the lesion infected the water-cooled lamp should be used.

Nervous System

Neuritis; Neuralgia (brachial, intercostal); Sciatica; Facial Palsy, etc.—Primarily, ultra-violet radiation is analgesic, and great relief is afforded in cases of neuritis and neuralgia, the radiation probably acting on the interepithelial nerve fibrils. It has already been mentioned that the intercostal neuralgia which is such

a common sequel of *Herpes zoster* in elderly people responds very favourably to ultra-violet radiation.

We have used this method of treatment in cases of sciatica, brachial neuritis, facial, intercostal and occipital neuralgia. In acute cases of sciatica relief is often obtained from the counter-irritant effect of applications of the water-cooled lamp to small areas along the course of the affected nerve.

This treatment can be used in other acute cases of neuritis, but it must be remembered that pigmentation will follow the reaction, and this precludes the adoption of this technique on exposed parts. Irradiation by the air-cooled lamp improves the condition of wasted tissues, relieves pain and paræsthesia and counteracts vasomotor spasm.

Neurasthenia.—Nervous symptoms associated with rickets, such as laryngismus stridulus, convulsions and tetany, are very quickly relieved by a few applications of ultra-violet radiation, as has already been mentioned in the chapter dealing with rickets. These symptoms are all associated with a low blood calcium content and owe their alleviation to its rise following irradiation. The irritability and fretfulness of rickety children are also manifestations of nervous hypersensitiveness, and are the first symptoms to be dispelled by irradiation.

It may be deduced from these facts that a low calcium content of the blood is one of the causes of neurasthenia in the adult; and when the blood of a neurasthenic is tested hypocalcæmia is invariably present. Actinotherapy may therefore be expected to give good results with these cases, and this has

been our experience. We have treated many cases of neurasthenia, and all except two have benefited greatly.

Treatment may be given to patients who still continue at their work. This is a great advantage, as it is unnecessary for the patients to go away, and solitude and its consequent introspection are avoided.

Patients invariably remark on the soothing effect of the rays, saying that often when they first lie on the couch they are "on edge," but gradually this feeling leaves them and they feel composed and inclined to sleep.

Another patient who had suffered for some time from neurasthenia, with fits of depression, remarked shortly after commencing treatment that she was beginning to see the funny side of things again.

The Commissioners of the Board of Control of Lunacy Cases, in their Report for 1925, comment favourably on the results obtained by treating neurasthenic patients with ultra-violet rays.

Chorea.—We have had excellent results in the treatment of chorea by ultra-violet radiation. There is soon a mitigation of the unpleasant symptoms and insomnia is relieved.

The time necessary to effect cure depends on the severity of the condition and the period which has elapsed since its commencement.

General irradiation should invariably be given, with first- or second-degree doses.

Spasmodic Torticollis is generally benefited by actinotherapy.

Paralysis agitans.—We have had an opportunity

of treating two cases of *Paralysis agitans* with ultra-violet radiation and diathermy. There has been very marked improvement in one case and slight improvement in the other.

The diathermy is most easily given with the Schittenhelm couch, and the actinic radiation applied over the whole body, back and front, with gradually increasing doses up to fifteen minutes back and front at twenty-four inches distance from the lamp. The exposures should be given twice or thrice weekly and continued for some time.

Locomotor ataxia.—Diathermy and general ultra-violet irradiation are often successful in alleviating the lightning pains which so often are such a dreadful feature of this disease.

Some workers have found that co-ordination is improved after prolonged treatment.

Anterior Poliomyelitis.—Very inspiring results have followed the use of ultra-violet radiation in this disease. The nutrition of the tissues is rapidly improved.

Murray Levick combines ultra-violet radiation with red rays obtained by passing the light from a carbon filament lamp through a red-glass filter. He finds these rays very valuable in treating atrophied and chronically inflamed tissues. Exposures of twenty to thirty minutes to this light are given daily.

Atrophy of the muscle fibres is prevented by daily faradic stimulation with the Smart-Bristow coil. The usual instrumental support, re-education of the affected muscles, and massage must not be neglected.

Long periods of treatment are, of course, necessary, but muscles which have been completely paralysed

for years, as a result of anterior poliomyelitis, have recovered when this method of treatment was adopted.

Encephalitis lethargica (*Parkinsonism* following). —Cures can hardly be expected in this disease, but the improvement in the patient's general health which follows ultra-violet treatment amply justifies its general use in this distressing malady.

Patients feel stronger and walk better, the appetite improves and the weight increases. Mentally, they appear brighter and more intelligent, speech becomes clearer and they rest better at nights.

Even this amount of alleviation means a great deal to the patient, and the treatment is worthy of prolonged trial in each individual case.

Ultra-Violet Radiation in Mental Diseases.—Dr Dove Cormac, of the Cheshire County Mental Hospital, has kindly given us the following information concerning the use of actinotherapy in mental disorders:

"In the few cases we have treated the results have been distinctly encouraging. I find that the maniac depressive cases have responded most readily, the period of depression being considerably curtailed, while the cases of pure melancholia do not seem to give such good results. In the delusional psychoses, where there is much mental irritability, due to the delusions causing excitement and impulsive actions, there has been a decided change of temperament. The patient has become more amiable, the delusions are seldom referred to and do not appear to trouble the patient so much while undergoing treatment.

"In dementia præcox, where there is a lowered metabolic rate, and one would expect some benefit,

the results have not been satisfactory. Generally the cases show an increase of muscular activity, and, with few exceptions, one is always greeted with a beaming smile."

Cases

Case 48. Female, aged 43 years, had suffered from periodical "nervous breakdowns" since she was twenty-eight years of age.

Later she was an unwilling spectator of some incident in the early stages of the Russian revolution, and the shock which she suffered as a consequence of this greatly aggravated her condition. Recently she had undergone a very trying illness, lasting more than twelve months, the beginning of which was a severe operation. She was a very highly strung, nervous woman, and since her illness had been unable to leave the house alone. She was afraid to cross the road or enter a tramcar, and said she had lost all confidence in herself, and had a constant dread of falling.

After sixteen exposures, extending over seven weeks, she was completely cured of her distressing symptoms, and was once more able to lead a normal life. After even the first few exposures the improvement was remarkable, and the patient was able to walk to and from the surgery and to find the exercise enjoyable. After two years the patient continues perfectly well.

Case 49. Male, aged 40, a commercial traveller, was troubled with sudden fears while travelling in railway trains, which caused him to get out of the train at some intermediate station without completing his

journey; he regained his self-confidence after the first few applications of ultra-violet radiation, and has remained well since.

Case 50. Female, aged 39, was suffering from nervous depression. She felt people were staring at her in the street, and had recently entirely lost her nerve at the thought of driving the car which formerly she had been able to take out with ease, and which consequently she had been unable to do for months. After the third application of the rays she was able to drive the car into town. After sixteen exposures, extending over one month, she was feeling quite well and happy, and has remained so for over eighteen months.

Case 51. Female, aged 55 years, was suffering from general weakness and wasting, accompanied by acute brachial neuritis in the right arm, owing to which she was unable to sleep at nights. Movement of the arm was impaired, and she was unable to do her own hair. The neuritis cleared up after a few treatments, but the irradiation was continued for her general condition. In all she had twenty-nine exposures, spread over eleven weeks, and improved wonderfully. The pain completely disappeared, she ate and slept well, and rapidly gained weight. At present she says she feels better than she has done for four years, and is bright and well and never feels tired now.

Case 52. Female, aged 35 years, suffering from psychasthenia. In April 1925 she went out for a walk and turned giddy, and afterwards did not care to go out alone. She also suffered from vague fears. Twenty-four general irradiations were made, with both the carbon arc and the quartz mercury vapour lamp, and

pigmentation was very marked. She resumed work at the termination of treatment in April 1926, and is once more perfectly normal.

Case 53. Female, aged 45, had suffered from *Paralysis agitans* for fifteen years. She greatly improved with diathermy treatment, and, as a result of it, had been able to knit, feed herself, and dress herself for the first time for several years. Latterly, we have combined the diathermy with ultra-violet radiation, with continued improvement.

Case 54. Boy, aged 13 years, contracted *Encephalitis lethargica* when he was seven years old ; this was followed by typical Parkinsonian symptoms. Since having general ultra-violet treatment he has been constitutionally stronger, his appetite has improved, he is speaking more clearly, his disposition has become brighter, he is sleeping better and he has progressed mentally.

Infectious Fevers

Ultra-violet radiation is particularly useful in the treatment of infectious fevers, especially after the acute febrile symptoms have abated. Cases of measles, rubella, scarlet fever, mumps and chickenpox have all been treated. The use of actinic rays in whooping cough and erysipelas has already been referred to. Diphtheria cases can be treated by the water-cooled lamp, and the use of ultra-violet rays for treating diphtheria carriers has been successful. In chickenpox the intense irritation is soon relieved by irradiation, and it is unusual, afterwards, to have permanent pock-marks.

Desquamation is expedited in scarlet fever cases. Raying is very convenient for relieving the intense pain which occurs in the affected parotid glands in cases of mumps; it may also be applied to relieve the orchitic pain which is present in about a third of the cases occurring in adult males.

Prophylactically, the rays can be used to increase the resistance of a patient subject to rheumatic fever, lobar pneumonia, etc.

Huldschinsky, describing two hundred cases of rickets which were treated at the Oskar-Helene Home for Crippled Children, Dahlem, Berlin, extending over a period of two years, says: "The children's constitutional power of resistance against affections of the lungs increased visibly. After the first month of ultra-violet-light treatment I did not lose a single child from broncho-pneumonia. During a severe epidemic of whooping cough, during which some thirty children fell ill, no child died, as all had been rayed. Measles, contracted by some fifty patients, also caused no deaths. Considering the number of cases of just these two illnesses terminating fatally, when contracted by rickety children, we can be justly proud of the exceedingly favourable results of our treatment."

We ourselves have had several interesting opportunities of noticing the power of raising body resistance which ultra-violet rays possess. Recently, in a family of six young children, five contracted acute tonsillitis, and only one escaped. Of the five children who had sore throats, the one who had it least severely was a very delicate child suffering from *Tabes mesenterica*. Two of the children had been irradiated with

the mercury vapour lamp. One of these escaped the infection altogether, and the other child who had been rayed had it least severely of all. This case, one of many, serves to demonstrate the prophylactic properties of ultra-violet radiation.

Diseases of the Eye

Before commencing treatment of the eye with ultra-violet radiation it must be remembered that all waves shorter than 2950 Å are absorbed by the cornea, and that rays with longer wave-lengths than 3050 Å have no abiotic action on the cornea.

The lens absorbs rays below 3200 Å, and in some cases even those situated higher in the spectrum. Old and very opaque lenses may absorb up to even 4000 Å. Therefore all rays above 4000 Å reach the retina, and in young and very transparent lenses those above 3200 Å. These, however, are all absorbed by the pigment in the retina and converted into heat.

Various workers have used ultra-violet radiation in the treatment of eye conditions with very encouraging results, but probably the most interesting recent contribution to the subject has been that of Stewart Duke-Elder.

Chronic conditions respond more favourably to treatment than acute, especially when these are tubercular in origin, and, naturally, superficial lesions are more easily treated than deep.

In these cases, as in most others, general treatment is very important, especially in tubercular cases and in children.

Blepharitis responds well to treatment. Local applications may be made to the everted lids by means of small quartz compressors, care being taken to protect the cornea and conjunctiva. One or two applications are generally sufficient to bring about cure. Eyelashes which have been shed grow again after irradiation.

Dacrocystitis, either tubercular or simple, may be treated by ultra-violet radiation with good results.

Trachoma.—The "Finsen" lamp has given excellent results in the treatment of these cases, which are often very stubborn with the usual methods of treatment.

Gronholm, at the Finsen Institute, reports on a series of ninety-eight trachomatous cases; seventy-nine were cured and the remainder were improved. There was no spread of the lesion in any of the cases treated. Relapses, however, occurred in twenty-one cases.

An intense reaction is caused by the rays, and the eyelids become œdematous. This may last for a week. When the reaction has subsided the lesions are found to have disappeared, with only a very superficial scar remaining.

Sometimes ten minutes' treatment is sufficient, but occasionally it is necessary to give two to six applications.

In only three cases treated was visual acuity decreased, though a fifth of the cases had corneal ulcerations.

Special forceps are used for everting the eyelids—these are illustrated on page 329.

Chronic Catarrhal Conjunctivitis.—There is generally improvement after the first treatment.

In tubercular conjunctivitis Lundsgaard advises prismatic compression, with an initial dose of thirty minutes with the "Finsen-Reyn" lamp. This is followed by marked œdema and swelling, which subsides in from three to six days after irradiation.

The quartz mercury vapour lamp may also be used, with doses of five minutes at eighteen inches. When using the "Kromayer" lamp great caution must be exercised. Doses of one to five minutes may be given. If the blue Uviol filter is inserted, five to thirty minutes' exposure is possible.

After exposure a false membrane is formed, which is thrown off when the reaction has subsided, but re-forms if removed before.

Phlyctenular Conjunctivitis gives very satisfactory results, especially in children, and when combined with general irradiation.

Keratitis.—Tubercular, syphilitic and kerato conjunctivitis, acne of the cornea, hypopion and serpiginous ulcers may all be treated with ultra-violet radiation, and good results have been obtained.

The best technique is to prevent the rays from falling on the pupil by using a curved quartz rod, which should be covered with black paper except at its tip.

If destruction of tissue is required, rays of shorter wave-length than 3000 Å should be used; if analgesic effect is desired, rays of longer wave-length are necessary.

Photophobia and blepharospasm are rapidly relieved in cases of phlyctenular keratitis and conjunctivitis.

The results of actinic treatment in interstitial keratitis and corneal opacities have not been very favourable.

Iritis and Irido-Cyclitis.—Ordinary methods of treatment are very unsatisfactory in tubercular irido-cyclitis, but these cases do exceedingly well with general ultra-violet radiation. The results in infective cases are not so satisfactory, but Dukę-Elder mentions 29 very severe cases, most of considerable duration: 5 cases were cured in a few weeks; 12 cases showed slower but steady improvement; in 8 there was an improvement in the general health, but not in the eye; and in 4 cases the eye condition became worse.

General treatment with the quartz mercury vapour lamp or the carbon arc is the method of choice.

Choroiditis.—General actinotherapy has given good results.

Chorio-Retinitis.—Birch-Hirschfeld has reported good results with the "Zeiss Redfree" lamp. He focuses the rays into the interior of the eye in this condition and also in *Tubercular retinitis.*

Technique: General.—Light baths should always be given, in the manner described on page 247.

Local.—The mercury vapour lamp is generally preferable to the carbon arc, as the radiation is comparatively cold. The eye should be cocainized before treatment. When treating the cornea and iris a bent quartz rod is most useful, as the beam of light is then more easily controlled.

The eyelids may be treated by everting them and then focusing on to them with a quartz lens the rays from an air-cooled mercury vapour lamp.

Sedative doses may be given through Chance's ultra-violet filter and a glass lens, as rays of wave-length longer than 3000 Å are the most efficacious for the purpose.

Diseases of the Throat

Acute Pharyngitis can be treated by irradiation with good results. The "Kromayer" lamp can be used with a quartz applicator and exposures of two minutes given at first, or a metal speculum may be fixed to the hood of the air-cooled lamp.

The "Landeker-Steinberg" lamp is also convenient for treating these cases. It is an arc lamp enclosed in a metal housing, to which various metal specula can be attached. The dosage depends entirely on the type of electrodes used, varying from five minutes with polymetallic or tungsten-cored carbons to thirty minutes or more with plain carbons.

Chronic Pharyngitis, in its varying forms, may also be treated in this way, and good results have been obtained.

Acute Tonsillitis. — A strong dose with the "Kromayer" lamp, using compression, directly applied to the affected tonsil, will generally give almost immediate relief. If this treatment is given at the beginning of an attack it is usually possible to abort it.

In bad cases erythema doses applied externally to the neck have a splendid counter-irritant effect.

Chronic Tonsillitis does not yield so readily to irradiation, but relief has been obtained in many cases.

If operation is refused in cases of hypertrophy of the tonsils irradiation should be the method of choice.

Œdematous enlargement will clear up entirely with actinotherapy, but true hyperplasia is not influenced.

Diphtheria.—Infection carriers, especially of this disease, may be effectively dealt with by means of the water-cooled lamp.

Laryngitis.—General irradiation is often of value in acute catarrhal laryngitis. When the condition has become chronic the methods described in the treatment of tubercular laryngitis on pages 338-342 may be adopted.

Spasmodic Laryngitis clears up under general ultra-violet baths. The general health is improved and the hypocalcæmia, which is invariably present, is corrected.

Diseases of the Nose

In all nasal conditions thorough cleaning of the parts before irradiation is, of course, essential, and all mucus and crusts must be removed.

Acute Rhinitis and Coryza.—Varying results are obtained in these conditions. Either the air-cooled or water-cooled lamp may be used. We have had very satisfactory results with our special applicators attached to the former. By this method exposures of from two to ten minutes may be given.

An attack of this annoying complaint can often be aborted if the nose is irradiated at the commencement.

If the water-cooled lamp is being used, Cemach's quartz applicator should be employed.

It must be remembered that the rays emerge only from the tip of the rod, so, to expose the whole mucous membrane of the nose, the rod must be first inserted as far as possible and an exposure given, and then drawn out almost to half of its length and another exposure made, and, finally, the third application to that nostril should be given with the applicator almost entirely drawn out. Each nostril should be sprayed with a ten to twenty per cent. solution of cocaine before it is attempted to introduce the applicator. General irradiation is often useful in these cases.

Acute Purulent Rhinitis can also be treated by one of the methods mentioned above, with good results.

Chronic Nasal Catarrh makes demands on the time and patience of both doctor and patient. But good results are often obtained.

The authors, who recently asked Cemach whether he got good results in the ultra-violet treatment of chronic nasal catarrh, were surprised when he said that, apart from accessory sinus trouble, the condition was unknown in Vienna. This can hardly be said of Britain.

Chronic Atrophic Rhinitis or Ozæna.—Our applicator attached to the air-cooled mercury vapour lamp may be used in this condition, or Cemach's applicator can be employed with the water-cooled. A few applications are sufficient to remove the characteristic odour. Permanent cures can be obtained in the early stages, when there is only a moderate amount of mucous membrane atrophy. Ultra-violet radiation can, even in very bad cases, always relieve the pain

and stop the smell. When syphilis is present the results are not good.

We have had very satisfactory results in the cases we have treated.

Irradiation should be given twice or thrice weekly, with gradually increasing doses. Strong doses of unfiltered rays are necessary.

Vasomotor Rhinitis.—Fifty per cent. of cases of this disease are cured by ultra-violet radiation.

Eczema of the Nose can be satisfactorily treated by actinotherapy. The treatment of tubercular conditions of the nose has already been described.

Hay Fever.—The results of ultra-violet treatment in this condition are surprisingly successful. This is all the more wonderful, when it is considered how resistant this disease is to ordinary methods of treatment, as the number of patent drugs alleged to cure hay fever testifies.

We have had excellent results after the use of our own applicator, which conveniently allows both nostrils to be irradiated together, and also with Cemach's technique. Eighty per cent. of cases can be cured, and the remaining twenty per cent. are sufficiently improved to be able to stay in the town without any unpleasant symptoms.

Cemach adopts the same procedure that he uses when treating ozæna or acute rhinitis, except that the rays are filtered through the blue Uviol filter.

Treatment should be given every day for a week, commencing on the first day with one minute's exposure to three separate areas in each nostril, which, of course, must be irradiated separately by this method,

so that each side of the nose is given a total of three minutes.

If there has not been any excessive reaction two minutes' exposure to each separate area is made

FIG. 164.—Our "Kromayer" Lamp fitted with Dr Cemach's Nasal Applicator being used for the Irradiation of the Nose. The use of the Adjustable Head-Rest should be noted.

on the second day, and one minute added each day.

On the seventh day a total of twenty-one minutes' exposure of each nostril will be given.

With the ordinary "Kromayer" lamp it is simplest to introduce the quartz applicator first, and then,

when it is safely in the nose, to attach it to the lamp. With the "Photostat" it is possible to introduce the applicator while it is attached to the lamp.

In hay fever the course of seven days' treatment should be given each year a few days before the time that the condition used to commence.

Case 55. One patient we treated was a schoolmistress who had been a martyr to hay fever for years. Before she had ultra-violet treatment she was using thirty handkerchiefs a day. After five minutes' irradiation she used only one handkerchief in the following twenty-four hours. She had three applications in all, but there was no return of any unpleasant symptoms after the first treatment.

In 1926 she was treated locally with the air-cooled mercury vapour lamp, by means of our nasal speculum. Six applications were made, the first of five minutes' duration, each nostril being irradiated simultaneously. General treatment was also given. Irradiation effectively prevented the reappearance of any symptoms of hay fever.

Case 56. Female, aged 36. Hay fever commenced when she was nine years of age. It usually began about the end of May or the early part of June and lasted until the end of July. The nose had been cauterized and the membrane incised. Inoculations with autogenous vaccines had been given for four years. General treatment with the mercury vapour and carbon arc lamps was given on twelve occasions and local treatment with the Cemach applicator on six. For the first time for twenty-seven years no symptoms of hay fever were experienced.

Case 57. Male, aged 40 years, had suffered from chronic nasal catarrh for two years, following a short sea voyage when he got very wet, and was unable to change his clothes. Seven exposures to both nostrils were made with the small carbon arc for from three and a half to seven and a half minutes. The catarrh did not occur again, and a year afterwards there had not been any relapse.

Sinus Affections have been treated by means of

FIG. 165.—Vernon's Nasal Applicator, which can be attached to the "Kromayer" Lamp. It however allows only one nostril to be irradiated at a time.

actinotherapy with varying results. In all cases general treatment should be adopted to increase the resistance of the patient against infection.

Antritis.—The water-cooled lamp may be used, in conjunction with general irradiation, to produce counter-irritation. The quartz rod can also be inserted into the cavity for local application. If pus is present the antrum must, of course, be drained.

Ethmoidal or Frontal Sinus Infection may also be

treated. After operation a quartz applicator may be thrust into the sinus.

Epistaxis.—The coagulating effect of the rays benefits epistaxis. A quartz rod should be introduced into the nostril.

General irradiation is very important in these cases.

Calcium lactate may be administered orally if there is a tendency to chronic bleeding.

Diseases of the Ear

Eczema of the external ear and auditory canal, canal furunculosis, chronic *Otitis media* have all been treated with actinic radiation. Dr Cemach says: "My experience, which extends over more than one hundred cases, has convinced me that the quartz lamp has now provided us with a means of treating eczema in the ear much more successfully than we have been able to do in the past." He advises ultra-violet radiation in perichondritis, a condition which previously was unsuccessfully treated by making large incisions. By conjoint radiant heat and ultra-violet radiation he has been able to cure cases without deformity in from two to four weeks. Inflammation of the external ear, when ultra-violet radiation is applied, soon improves; the rays ease the pain, stop the inflammation and promote resolution.

Case 58. We treated a case of perichondritis of the nose, which had recurred several times after carbon-dioxide-snow applications. Although only three exposures to the air-cooled lamp, for from five to ten minutes, at a distance of twelve inches, were given,

improvement was noticed. During treatment the patient wore a child's mask, the eyeholes of which had been covered up and an appropriate area removed to allow the lesion itself and normal skin about a quarter of an inch beyond it to be exposed. Unfortunately, the patient did not continue treatment.

In cases of *Otitis media*, whether simple or tubercular, applications can be made to the tympanum, or to the middle ear if the drum is destroyed. Either the air-cooled lamp and a speculum or the water-cooled lamp with a quartz rod can be used. In the case of the former, exposures of two and a half to ten minutes at a distance of eight inches, or even less, can be given. With the "Kromayer" lamp, doses of one-fifth of a minute to five minutes.

Very good results have been obtained, especially with children; discharge has ceased and hearing has definitely improved.

Suppurative Mastoiditis cases which have been operated on, but refuse to heal, respond well to ultra-violet radiation. Both general and local treatment should be given.

Early cases may sometimes be aborted by blister doses applied to the mastoid region, and in some acute cases operation may be avoided.

In all these conditions of the external and internal ear general irradiation must always be carried out in addition to local exposures. In diseases of the internal ear all pathological conditions of the throat and nose must, of course, be attended to.

Uses of Ultra-Violet Radiation in Dental Practice

Mellanby has recently shown that exposure of the body to ultra-violet rays greatly improves the calcification of the teeth, and considerably lessens the risk of subsequent dental caries. It also increases the bactericidal properties of the blood, which indirectly diminishes the risk of microbic infection.

Ultra-violet radiation, therefore, seems destined to play an important rôle in dental prophylaxis.

Gingivitis.—This is any type of inflammatory condition which is evident in the gums.

To obtain beneficial results in actinotherapy optical contact must be obtained—that is, there must be no opaque material interposed between the source of radiation and the site of infection undergoing treatment.

It can readily be understood that this is very difficult to attain in many dental cases where it is desired to use ultra-violet radiation.

The method which is most effective is to paint eosin, or some other photosensitive paint, on to the gum and gum margin, or to inject it into the tissues. Capillary attraction and absorption ensures the impregnation of the periodontal membrane with the photosensitive solution, and it may finally even penetrate as far as a periapical abscess.

After the gum has been painted with an aniline-dye solution the water-cooled lamp, fitted with a quartz rod, should be firmly pressed on to the area, which it is desired to treat.

Exposures of, first, one minute to each part, increased by a minute at each subsequent sitting until ten minutes is being given, should be made to each separate area.

Ultra-violet radiation stimulates the tissues of the mouth, and the gums and teeth become firmer.

FIG. 166.—The "Uviarc" Water-cooled Mercury Vapour Lamp being used with a curved Quartz Applicator for Irradiation of an area on the Lingual Surface of the Gums.

Rowlett records an obstinate case of gingivitis, of several years' duration, which was cured by three treatments, of twenty minutes each, with the "Landeker Steinberg" carbon arc.

Pyorrhœa alveolaris.—At present there are great differences in the results of different observers in the treatment of pyorrhœa alveolaris. X-ray examination of suspected teeth is, of course, essential. Then

thorough, deep scaling should be carried out, followed by actinic radiation with :

(*a*) The "Kromayer" lamp.

(*b*) A small carbon arc lamp taking about six ampères, such as the "Sunic" parallel carbon lamp or the "Arnone" lamp.

(*c*) A tungsten arc lamp, such as the water-cooled "Pashler" lamp.

With the "Kromayer" lamp treatment every other day is advised, special quartz applicators being used to render the tissues anæmic and localize the rays, which should be applied to both the facial and lingual surfaces of the gums.

A first exposure of one minute to each area treated is generally given, and a second of two minutes, an extra minute being added for each application.

If a blister should happen to form a week is allowed to elapse and the last dosage given is repeated.

In successful cases the pus disappears after two or three applications, the œdema of the gums subsides, and the teeth gradually become firmer.

We must confess that our own results in the few cases of pyorrhœa we have treated have not been very satisfactory.

Reed, in an article in *The Dental Magazine* of May 1922, describes various cases he has successfully treated with the "Pashler" type of water-cooled tungsten arc lamp, concentrating the rays through a quartz lens. He says ultra-violet rays have a considerable curative effect in cases of gingivitis.

A first application of two minutes to one area, gradually increased to ten minutes, will quickly cure

gingivitis of local origin, if the original cause is first removed.

Dr Galbreath, of Montreux, in 1925, demonstrated

FIG. 167.—The "Arnone" Stand Model of Carbon Arc Lamp taking 3 to 8 ampères D.C. or A.C. This Lamp is designed for Dental Treatment.

the "Arnone" lamp to us. He has successfully used it in several different conditions found in the mouth, and prefers it to the "Kromayer" lamp for dental

work, as he says it does not cause the intense reaction which the last-named does.

He describes a case of Vincent's angina, in which the first application of the rays relieved the pain, and six subsequent applications effected a cure. His technique is four minutes' exposure of the front teeth and three minutes' of the side, gradually increasing to five minutes, the applications to be given every second or third day.

He describes the remarkable results the rays have in the prevention of pain. A case of periodontitis, which had had incessant pain for two days and two nights, was relieved by three and a half minutes' irradiation. Soreness of teeth after root filling, and pain after extractions, are quickly relieved, the gums generally healing by first intention. A condition where the rays cannot be used is in diseases of the dental pulp, an increase of pain being provoked in as short a time as thirty seconds. In fact, the rays can be used for establishing a differential diagnosis between the early stages of periodontitis and unsuspected pulpitis.

For Whitening Teeth.—The use of actinic rays for whitening live teeth provides a method which is free from the risk of causing decalcification, or irritation of the gums or dental pulp. The tooth, which it is desired to whiten, is first isolated by means of a rubber dam. Next, a piece of cardboard is provided, which has a hole in it corresponding to the patient's open mouth. The protective rubber is attached to this cardboard. The tooth is then moistened with hydrogen peroxide, which must be free from any acidic

impurities, and the actinic rays directed on to it for periods varying from ten to sixty minutes, as required. Usually ten minutes is quite long enough. Two or three treatments are generally all that is necessary.

FIG. 168.—A special Carbon Arc Lamp designed for Irradiation of Chickens. Any falling pieces of Carbon are caught on a Vitaglass Tray which is suspended below the Arc. The mortality of young birds has been greatly lessened by the use of Ultra-Violet Rays.

Most stains of organic origin can be removed in this way, but metallic discolorations are not affected.

Veterinary Uses of Ultra-Violet Radiation.—Ultra-violet radiation has only recently been used in

veterinary work, but there seems to be endless scope for its beneficent use in the treatment of animals.

A recent example of the prophylactic employment of ultra-violet radiation has been the installation of ultra-violet apparatus in the new monkey-house and reptile-house at the London Zoological Gardens.

Professor Cinotti, of the Naples Veterinary School, has found ultra-violet radiation very useful in cases of parasitic dermatitis, such as mange. We have recently cured a cat suffering from mange with ten applications of the rays.

Cases of acute and chronic eczema and seborrhœa also quickly respond to ultra-violet radiation.

In conclusion, the reader will appreciate, from a perusal of the foregoing pages, the value of ultra-violet radiation in many varying conditions.

In some its action is almost specific, but in the great majority it is an invaluable adjuvant supplementing other forms of treatment.

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